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GIRLS IN ELEMENTARY SCIENCE: A CASE STUDY

by

BRENDA J. GUSTAFSON

(C)

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

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GIRLS IN ELEMENTARY SCIENCE: A CASE STUDY

submitted by Brenda J. Gustafson in partial fulfillment of the requirements for the degree of Master of Education.

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Date August 26, 1985

ABSTRACT

The purpose of the study was to explore the meanings and understandings of school science which a small group of grade six girls hold, particularly as revealed through their experiences of hands-on science activities. The methodological framework was that of a case study and specifically involved ethnographic recording of classroom description, interviews with study participants, and the writing of a daily journal.

A number of themes arose from the discussion of hands-on activities which emphasized how the girls saw these experiences as allowing them to be personally involved in the learning, be more autonomous, and experience school science as analogous to everyday life. Additionally, the girls expressed reservations about the applicability of some science curriculum content to their lives and when combined with their comments on hands-on activities served to highlight how elementary science is influenced by various factors associated with the structure of the school. These factors were discussed in detail and accentuated the web of interconnections which can potentially affect the teaching of elementary school science.

Finally, the girls suggested ideas about how school science could be transformed into an activity that is more characteristic of human life. They specified the merging of the roles of student and teacher, a curriculum which has personal meaning to their everyday lives, a view of teachers as helpers, and an increased sense of freedom. The study concluded with

recommendations for further research connected to this topic area.

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I INTRODUCTION

"... science is a characteristic activity of human life."

(Bronowski, 1978, p. 104)

This sense of science as a fundamental human activity awakens a recognition of the intermingling between what already exists naturally in our lives and what we designate as science. Both science and human existence embody the spirit of inquisitiveness, a longing to know our creation, environment, and future. As we participate in the dynamics of life and science we eternally seek, select between alternatives, search for unity, anticipate outcomes, and endure error. Science and life both involve an exploration of the world, our Selves, and an attempt to understand the meanings we uncover. We participate in an endless cycle of wonder, reflection, and action which is the precursor of a knowledge we pursue during every facet of human life: a wisdom to know and to do what is right as we share and experience the world with other people.

If it is true that science and human existence are at least in some ways mutually inclusive, then perhaps our formal instruction in science should be a subsumption of the experience of life. Each involves some of the same processes of learning, and both are thoughtful actions directed toward a future. But, is it reasonable to expect our academic, institutional experiences in science to reflect the richness and diversity of human experience? At the conclusion of our formal studies should we be

left with a sense that we have lived life? Or, can we only anticipate fleeting moments in classroom science when we feel a real participation in learning, an expansion of horizons, stirrings of autonomy, and the touch of wisdom?

Perhaps if we wish to probe these questions of the relationship between institutional science and life, we could begin by directing our gaze towards the experiences children have in elementary school science. A concern about the association between formal science and children's lives suggests that we might begin by exploring school science within the confines of the classroom, while paying particular attention to the words children use to describe their existence there. Apple and King (1976) advise that "to understand the social reality of schooling it is necessary to study it in actual classroom settings" (p. 118), and Sitton and Mehaffy (1978) reason that "the culture of childhood in educational settings can only be known through the perspectives of children" (p. 521). Perhaps by speaking to children as they live the experience of school we may gain in our understanding of how students perceive school science and discover if it at any time resembles a characteristic activity of human life.

A) Towards This Study

In research studies such as this, the reader is often not told how the researcher's personal history affected the design, focus, discussion, interpretations, and conclusions of the study.

Both Battersby (1981) and Robinson (1974) have called attention to this hiatus in research literature. Battersby (1981) argues that each researcher has a unique set of biases and perceptions, a point which Robinson (1974) uses as the basis for his argument that researchers should make their intellectual stances clear. Because my personal history, view of children, and opinions of institutionalized education have most decidedly contributed to the focus, boundaries, interpretations, and conclusions of the present study, I will commence by examining incidents and experiences in my own life which will perhaps eventually provide additional insight into the topic of this study.

1. Beginning the Way: Perhaps this survey should start with my own initial experiences of institutionalized science. These formative experiences served as the foundation for my own view of science, for my eventual career choice, and for the concerns I pursued in graduate school, all of which contributed to the questions for this study. In this regard, my recollections of elementary school science could be described as primordial experiences predisposing me to feelings of contradiction about the nature of school science and Bronowski's portrayal of science as being a characteristic activity of life.

I cannot recall engaging in hands-on science activities as a student in elementary school. Instead, I and the other children spent our time designing title pages, copying notes from the board, and sketching pictures found in the textbook. Elementary school science was definitely something which I saw as controlled,

directed, and assigned by the teacher as, admittedly, were the other subjects. Consequently, student participation in making the science personal was minimal, and although I found the content interesting it seemed that my role was that of an outsider.

At that age level, I began to discern incipient feelings of a conflict between school science and the science I lived during my everyday life. This was disclosed through my extra-curricular activities. It seemed that the nature hikes, environmental studies, and science hobbies of my spare time bore little relation to the science allied with school. Although I sensed this gap, I did not assert my opinion but remained a conscientious student who would silently carry out all assignments teachers gave me. This silence was probably a result of my socialization into the culture of school, my personality, and the discouragement at home of extensive critique and reflection on the status quo.

As I continued through grade school I maintained interest in science while resigning myself to the apparent fact that school science had only a tenuous relationship to everyday science. Although I saw similarity between the science topics I was exposed to in both situations, it seemed that the process by which I learned this content was discrepant. Rather than question this variance, I reasoned it was just the nature of school and if science was to be taught within a classroom there had to be restrictions.

My role as a student gave way to that of a teacher upon completion of my training in elementary education. My teacher education reflected the impact of post-Sputnik science curricula

and philosophy, and I was guided to present elementary science using hands-on, inquiry oriented methodology. The rationale behind this approach to science education seemed more compatable with Bronowski's vision of science and life than did my own experiences in elementary school science. As I tried to implement this philosophy by emphasizing a program of concrete activities, I was able to observe the reactions of my students, and feel the restrictions of working within layers of bureaucracy.

My students welcomed the opportunity to leave their desks and work on hands-on activities with a small group of their peers. Initial hesitation about manipulating unfamiliar materials would fade as they gained in confidence and expertise. Towards the end of the school year they would possess the ability to select a topic of personal interest and pursue independent study. I also preferred the more relaxed atmosphere of the class when I was not the lecturer or dispenser of endless information. It seemed that when the children were given the opportunity to be personally responsible for their own learning, school science took on those characteristics of curiosity, personal participation, anticipation, and wonder which I suspect are what Bronowski thinks make it a life experience.

The preceding comments notwithstanding, I did experience attendant pressures as a science teacher which served to limit the amount of class time I could devote to hands-on science activities. Restricted access to science equipment and materials, professional responsibility to complete curriculum guidelines within the school year, disagreement with colleagues about

appropriate teaching strategies and noise levels, preparation for standardized science achievement tests, and rehearsal of lesson presentations all served to affect the frequency of these activities. I was aware that my role as a science teacher was to some degree being defined by the system I was a part of, and this recognition furnished a source of frustration, sense of restriction, and a questioning of my personal efficacy.

2. Finding My Question: My awareness of a gap between what school science was and the science that was part of my life, my silence as a student in elementary school, the recognition in my university curriculum courses of a humanistic approach to science, my own observation of my students, and my experiences as a science teacher were elaborated upon in graduate school and underwent a kind of synthesis that gave rise to the questions for this study.

Although one might think that educational research must surely be dominated by concern for the experiences children have in school, my readings and discussions with colleagues showed this to be an area which has largely been neglected. I could only locate the occasional research article which spoke about how it was for the children in our classrooms. This dearth of research is perhaps related to the methodologies which have historically dominated educational research, to research priorities that have been assigned largely to other topics in education, or simply, to the personal preferences of researchers for other areas of inquiry. Whatever the combination of reasons, a general concern about children's experiences in school science seemed to be a

topic which could perhaps provide insight into how students experience and understand their involvement in our classrooms.

This concern for the experience children have in elementary science gives rise to numerous questions: How, for example, do children speak of various classroom activities in science?; Are they able to state preferences?; How do they describe hands-on activities?; What curriculum content do they enjoy?; Do they experience school science as a characteristic activity of their life?. The number of questions could be infinite, and the answers perhaps as varied and unique as children themselves. Restricting my attention to the experience children have of hands-on science activities, however, promises to illuminate a portion of the elementary school science experience and also render this study more manageable.

Further, some recent research literature has drawn attention to problems encountered by girls in school science. Factors such as family background, socioeconomic status, cultural expectations, sexual stereotypes, enrollment patterns, attitudes, textbooks, and teachers have all been explored as influencing the low participation rate of girls in some high school science courses, girls being academically outperformed in science by boys, and an underrepresentation of women in science careers. These visible outcomes are thought by many to have their roots at least in part in the elementary school science experience. In a Science Council of Canada report, Who Turns the Wheel?, Janet Ferguson (1981) comments that an improvement to the current situation "depends on

our ability to interest girls in science in early elementary school" (p. 102). The Science Council of Canada Report 36 (1984) also voiced concern for girls in science and commented that "the experiences of girls who study science in Canadian schools have scarcely been examined" (p. 68). It seemed that a further narrowing of this study to a group of female elementary students stood the chance of providing an additional perspective on the Science Council's comments and would also begin to address the lack of Canadian research in this area.

The questions for the present study, then, evolved from personal experience and interests. Although it could not be foretold what insight might be attained, I was hopeful that at least a nucleus of understanding would form. My initial question -- What is the experience children have of elementary science?-- was inclusive in that it would require a survey of the entire experience of school science for children in an elementary classroom. Narrowing the question to an exploration of the meanings of hands-on science activities for a small group of elementary girls promised to inform this concern. Additionally, given this question and the potential meanings that may emerge, perhaps we may further understand Bronowski's (1978) statement claiming that science is a characteristic activity of human life. Finally, with this choice of topics and subsequent modifications I began my search for an understanding of how a group of girls might describe their involvement in hands-on science activities, and what this could tell us about possible connections between school science and what we call life.

II REVIEW OF RELEVANT LITERATURE

A) Past Emphasis

The dominant paradigm in recent science education research has been an empirical-analytical paradigm which is an approach to research borrowed from the natural sciences and focused on the testing of hypotheses. Many reasons have been suggested to explain why such methodologies have come to be seen as appropriate for the study of human beings. One argument suggests that by adopting natural science methodology we would see an advancement in the social sciences analagous to the achievements of the natural sciences. Another is that social science research lacked rigor and legitimacy and could only be acceptable as valid research if it emulated the techniques and precision of the natural sciences.

This over-use of the empirical-analytical paradigm has recently been subject to criticisms from some researchers. These researchers have argued that this paradigm has been so narrow in focus that it does little to add to our understanding of human beings, that it is alienated from the realities of the classroom and holds isolationist views of individuals in society. This has led to some researchers being outspoken in their condemnation of the 'scientific method' and 'positivistic philosophies' as they have been applied to educational research. Other researchers have taken the view that perhaps the empirical-analytical paradigm can add to our knowledge of education, but that it only represents part of the picture and should be complemented with

qualitative methodologies.

Robinson (1974) is critical of the use of the dominant paradigm when he comments that "the constant search after the methodology of the natural sciences has produced some sophisticated and elegant statistical techniques but has done little to enhance man's understanding of man" (p. 252). West (1977) states that the dominant paradigm "fails to take account of the unique nature of human subjects, who do not respond to 'forces and factors' as mute and fully determined atoms but as thinking and evaluating actors" (p. 58). These criticisms of the dominant paradigm and its natural science methodology are repeated in some research papers and appear throughout that part of education research which categorizes itself as human science research.

Lutz and Ramsey (1974) provide an interesting argument against this kind of reasoning when they suggest that the social sciences adopted only a selected part of the natural science methodology and in doing so, ignored the empirical element of that method:

> One of the major problems in the social sciences is that we have forgotten that most of the laws developed in the physical sciences were discovered because the operational phenomenon was noted first in the empirical world. The theory from which the hypotheses were derived was grounded in reality. These hypotheses were carefully related to that grounded theory. In the social sciences we have run from that investigation of empirical, operational reality, in an attempt to become 'scientific'. Thus we have omitted an important and necessary step in the development of hypotheses, theory, laws, and of a science. The use of anthropological field method can re-establish that step and move us significantly toward a science applicable to the study and operation of the educational enterprise. (p. 6)

But, despite the criticisms, arguments, and defenses that are proposed, it stands that education research has tended to ignore naturalistic studies in classroom settings with the result that "all too often our theories are developed in isolated research settings, and become 'theories' in the worst sense - irrelevant to everyday life in schools" (West, 1977, p. 62). Perhaps our understanding of the classroom, and how children speak of their experiences in it, can be enhanced by using ethnographic methodology to study the actual situation that they live on a daily basis. Robinson (1974, p. 263) concludes by urging us to "bring research back to the researched" by observing classrooms and sharing our analysis of the events with the children as they happen.

B) Towards Another View in Science Education Research

> In its position in the spectrum of research fields, science education is certainly susceptible to some empirical methods. It is also conceivable that the artistic aspects of science education, especially instruction, might be better understood if analytical methods from such fields as literature, the fine arts, and aesthetics were employed.
> (Lowery, 1980, p. 276)

In an effort to help us towards a further understanding of how children are influenced by the classroom context, what meanings they give to school science, and how they change over time, we need research methodologies which allow us the flexibility for this expanded vision of research. Arguments for the use of new research paradigms in science education have been presented by Roberts (1982), Wagner (1983), and Lowery (1980).

Roberts (1982) presents the view that qualitative research should be encouraged to share a complementary status with quantitative methodology. He argues that "the generation and development of knowledge is a matter of putting a construction on reality ... reality is interpreted through concepts and constructs of one sort or another" (p. 278). When we choose a methodology to study children in science, we are actually choosing a set of concepts and constructs through which we hope to view a part of the phenomenon. But, what we should pause to consider is whether our over-use of the dominant paradigm has led us to believe that this is the only way to research a question.

Roberts (1982) uses Pepper's (1942) six world hypotheses (animism, mysticism, formism, mechanism, contextualism, and organicism) to describe the many approaches mankind has taken to interpret the world. He suggests that by emphasizing that power is precision, educational research has tended towards using formism and mechanism to the exclusion of contextualism and organicism. He sees contextualism and organicism as able to provide us with greater scope by establishing the event to its context and helping us to see how different factors form together into an organic whole. This approach to children in science might allow us to take a step back from current research to see the patterns and interrelationships which make this subject part of a far greater whole.

Wagner (1983) uses the backdrop of Thomas Kuhn's book The Structure of Scientific Revolutions to formulate an argument that in science "it is only when a research paradigm fails to

generate new puzzles or to serve adequately as a heuristic for the puzzles which have been formulated does the scientific community become receptive to a new paradigm" (p. 609). If an analogy can be drawn to science education research, perhaps the contradictions, limitations, and questions that we see in current empirical-analytical literature suggest that there are other ways to explore a problem. In this respect, maybe qualitative methodologies can be seen as being remedial and not a revolution aimed at breaking down existing practices.

Lowery (1980) comments:

> That science education is still in an early fact gathering stage is evidenced by any review of research and by the current lack of organized, systematic effort to relate or follow up possibly significant bits and pieces of information derived from investigators. (p. 277)

He argues that regardless of the methodology used, we will not attain a cohesive body of knowledge without a guiding framework. In an effort to improve the science education research enterprise he suggests that we must go through three stages: fact gathering; natural history; and theory formulation. These three stages will allow us to propose additional questions that go beyond the asking of such questions as: "Does a given technique help? or Do individuals benefit from teaching technique A more than teaching technique B?" (p. 279). It is hoped that this creation of frameworks will "cause researchers to organize facts and set them against a rational, holistic system that has <u>educational</u> importance. At the same time, their creation will serve as a basis for examining these facts, generating banks of cohesive information, and developing fresh research methodologies

appropriate to the enterprise" (p. 208).

In some current science education literature, there seems to be a gradual recognition that there are many questions which could benefit from a different methodological approach. These questions cannot be answered by using 'scientific' methods and statistical procedures. Instead, we must look to other fields for methods which would allow us the increased insight and understanding that would complement our present knowledge.

C) Science Case Studies

Many researchers have attempted to gain partial insight into how children experience school science. Recently, several researchers have used the framework of a case study to also look at the experience of school science.

Two major case study projects have been carried out by the Science Council of Canada and the National Science Foundation. These provide ethnographic description of a wide variety of science classrooms in North America. A third set of case studies by Kelly (1981) provides excerpts from essays and conversations of girls enrolled in science classes in Britain. The passages that she has selected for discussion are meant to illustrate some of the themes of the book they are contained in. In addition, she attempts to present the teachers' point of view of girls' performance in science by reprinting letters which were sent to her by practicing science teachers. These qualitative studies will be discussed in more detail in the following sub-sections.

1. Science Council of Canada: In 1984, the Science Council of Canada published a series of case studies of science teaching at each of three broad division levels.

The majority of the case studies tended to focus on the observation of classroom events and on interviews with teachers. Teachers were encouraged to discuss their ideas of science education and teaching, and to talk of their personal experiences and frustrations in coping with the dilemmas they face on a daily basis. This case study emphasis provides the reader with a feeling for science as seen through the eyes of the teacher.

Throughout these case studies, however, there are scattered conversations and comments from the students. The only researcher who discussed these comments at any length however, was Pierre-Leon Trempe (1984). Trempe talked with students who were in their senior years of high school and asked questions as to what they were doing and why. The theme of alienation emerged from the analysis of his interviews and observations, and he went on to discuss this theme in detail.

2. National Science Foundation: In 1978, the National Science Foundation in the United States sponsored the publication of a series of case studies in science education which were co-directed by Robert Stake and Jack Easley. These case studies were carried out during the 1976-77 school term and attempted to portray conditions in K-12 science classrooms. These case studies emphasized comments from teachers, science coordinators, parents, and superintendents. Observations of classrooms, an

analysis of a questionnaire, and some student dialogue relating to job prospects, curriculum, and opinions on school science were also included in the report.

3. Kelly: In her book called The Missing Half: Girls and Science Education, Kelly devotes two chapters to presenting the viewpoints of students and teachers who are involved in science education.

After placing an advertisement in several British education newsletters, Kelly received a number of responses from schoolgirls who were willing to comment on their experiences of science education. She cautions that the selections she chose to reprint are not a randomized representation of schoolgirl opinion in the country, but were rather selected for the variety of views presented. Kelly comments that the essays should be read "as illuminating and complementing the more rigorous studies" (p. 232).

Kelly attempts to identify some of the themes emerging from the schoolgirl essays. These themes are: girls may be isolated and ignored in some science classes; science is a boy's subject; some girls have to fight to enroll in science; science may have timetabling conflicts with other subject areas; and parents and peers can influence choice of science in school. After giving quotes from essays to support her thematic analysis she then details a conversation between two girls who are enrolled in a physics class at school. During the conversation, the girls discuss the fact that they feel uncomfortable in class due to the sexism that dominates classroom interactions. They feel that the

classroom climate not only embarrasses them, but serves to undermine their confidence in that subject area.

Kelly then deals with the viewpoints of teachers who submitted letters on why they feel many girls underachieve in science and suggestions as to what can be done about it. These teachers frequently refer to differences in intellectual style between boys and girls along with a variety of educational and social factors.

D) Research on Hands-On Activities

Except for the occasional comments about hands-on activities that students outlined in the previously mentioned case studies, the majority of the research in this area is of a quantitative nature. These research studies use questionnaires, tests, and a variety of survey instruments to focus on student performance, attitudes, and the program effectiveness of activity-centered classrooms.

Several studies have examined the amount and variety of teacher intervention in teacher structured and student structured activity-centered classrooms. Shymansky (1978) and Shymansky and Penick (1981) observed that when students are exposed to highly non-directive teacher behaviors where they are allowed to pursue their own ideas and evaluate their own results, the children showed increased curiosity, enhanced positive attitudes, remain on-task, and exhibit more independence. The researchers summarize that

if teachers wish to minimize disruptive behavior, reduce

> copying, hand-waving, and general unpredictability, the conclusion seems clear - reduce the teacher's classroom control over directions and evaluation by giving students more responsibility for their own learning. (Shymansky & Penick, 1981, p. 421)

Shymansky, Kyle and Alport (1982) conducted a survey on the effectiveness of activity-centered versus traditional science programs. They found that students in activity science programs consistently outperformed those in traditional classrooms on every criterion measured. Gains in achievement, attitudes, process skills, related skills, creativity, and Piagetian tasks were observed in students enrolled in activity programs. Bredderman (1982) also discussed the influence of an activity program and agreed that children benefited from enrollment in these classrooms. He concluded:

> With the use of activity-based science programs teachers can expect substantially improved performance in science process and creativity; modestly increased performance on tests of perception, logic, language development, science content and math; modestly improved attitude toward science and science class; and pronounced benefits for disadvantaged students, less or none for advantaged students. (p. 41)

Other studies have attempted to focus on children's attitudes toward science as a result of being exposed to a hands-on activity program. Jaus (1977) administered a questionnaire to children in grades three and four and found that hands-on activities improve their attitudes toward science and perhaps assist in positive attitudes toward school. Johnson, Ryan, and Schroeder (1974) attempted to ascertain the attitudes of grade six students toward school science and found that children "who interacted with concrete materials (batteries,

bulbs, wire) to answer questions developed significantly more positive attitudes than ... students studying similar subject matter from a textbook" (p. 55). Johnson (1976) and Johnson and Johnson (1974) examined the cooperative environment of hands-on science classrooms and found that in contrast to the competitive format usually associated with school, children preferred this atmosphere. They speculated that subsequent positive attitudes toward school may in part be due to the opportunity to work with other students in these cooperative surroundings.

E) The Present Study

The researchers involved in case studies of science education in Canada, the United States, and Great Britain raise many questions about how children experience school science. Additionally, other researchers have focused on hands-on science activities and have attempted to comment on program effectiveness and children's reaction to enrollment in activity-centered classrooms.

A third group of studies which draw attention to the experience of girls in science were briefly commented upon in the first chapter of the present study. These empirical analytical research studies have been particularly valuable in identifying factors which relate to the experience of girls in science, and have been most helpful in clarifying the questions that were asked by the researchers. However, the methodological and

philosophical frameworks which these researchers used are quite different from what is intended in the present study. First, these empirical-analytical studies inevitably are focused on a comparison between boys and girls. There is perhaps already reason enough to believe that the experiences of girls is in some times and places, and to some degree, different from that of boys. At any rate, in this study I wish to come to a better understanding of the experience of girls. Secondly, the empirical-analytical mode tends to see children as isolated from their environment. The assumption is made that if we can identify causes, then compensatory means for correcting deficiencies can be instigated. Instead, I see children as embedded in their world, and as people with whom understanding can be mutually interpreted and shared. Because these differences limit the degree to which the studies referred to can inform my own, I will not discuss them in detail. Instead, I will be listing these studies in the Bibliography section of this study and recommend them as another perspective into children and science.

The questions to be addressed in the present study are those which deal with the personal experiences of girls and with the meanings they give to school science, particularly as revealed through their experiences of hands-on science activities. My wonder of how it is for children in science classrooms suggests the use of qualitative methodologies which will allow me to observe and interview a small group of girls as they live this experience. These methods will be contained within the flexible

framework of a case study. Stake (1978) comments that the aim of a case study is "understanding, extension of experience, and increase of conviction in that which is known ..." (p. 6). If this is to be the case, then the situational-interpretive study of the kind that I am proposing seems most appropriate for the study of my questions.

III RESEARCH DESIGN

A) What is a Case Study?

A case study involves the use of qualitative research methods to tell the story of a focused situation. Stake and Easley (1978) state that

> The case study is a study of a bounded system, emphasizing the unity and wholeness of that system, but confining the attention to those aspects that are relevant to the research problem at the time. (p. C:31)

The present study involved the bounded system of a grade six classroom during the times when science was being taught. I focused the majority of my attention on six girls who served as my key informants. This research cannot be considered to be an ethnography because of the short time span of the study, although I did use ethnographic methods to assist me in describing the case.

> So what is being studied is the case. The case is something deemed worthy of close watch. It has character, it has totality, it has boundaries .... It is a complex, dynamic system, something to be thought of as an existing entity, even when simple descriptions are being made of it. The case study tells a story about a bounded system. (Stake & Easley, 1978, p. C:30)

1. Participant Observer: My stance as the researcher in this case study was one of a participant observer. Various definitions have been suggested for this term, but most of them center around the idea of going to a setting, participating to some degree in the life of the people, and observing their

actions and conversations.

Agar (1980) states that participant observation "suggests that you are directly involved in community life, observing and talking with people as you learn from them their view of reality" (p. 114). Spradley (1980) seems to echo Agar's definition when he comments that "the participant observer comes to a social situation with two purposes: (1) to engage in activities appropriate to the situation and (2) to observe the activities, people, and physical aspects of the situation" (p. 54).

Robinson (1974) quotes Denzin (1970) who suggests that "participant observation involves the collection and analysis of documents, interviewing people with different perspectives, particularly those with 'key' information, as well as direct participation in the activities of the group" (p. 259). Ahola and Lucas (1981) use Becker and Geer's (1969) definition which also speaks of participation in the daily life of the people, "observing things that happen, listening to what is said, and questioning people, over some length of time" (p. 322).

Clearly, these definitions have a common thread running through them. They all speak of going to a setting and engaging in activities that would allow the researcher to gain an understanding of how life is for the people in that situation. But, there also seems to be a question about the degree of participation that the researcher may be involved in. Sometimes a researcher may take part in all facets of a community in an attempt to experience the life of the people as closely as

possible. In other studies, a researcher may be a more passive participant and rely more on journal notes and interviews with key informants.

For this study, I observed science lessons while seated at the back of the classroom. When the students were directed to leave their desks for group work or to come to the front of the class to observe a teacher demonstration, I would also leave my seat and go with them. I did not actually do the science activities but, rather, would stand close to a group and take written notes of what I observed. During filmstrips and teacher lectures, I would listen to what was being said and record students' comments and movements as they took place. I was also given some documents to look at such as tests, worksheets, and activity handouts. However, the majority of my data came from interviewing six of the girls in the classroom. In this way, my case study was narrowed down to describing how the science class was for them and my role as a participant observer keyed on their activities, lives, and comments.

2. Interviewing: The rationale for interviewing the girls was based on the idea that we can learn how people think about the world by attending to how they speak of it. Such interviews are based on the assumption that people are able to

> describe their own life-world, their opinions and acts, in their own words. In contrast to the multiple-choice questionnaires with questions and answers already formulated by experts, the interview makes it possible for the subjects to organize their own descriptions, emphasizing what they themselves find important. (Kvale, 1984, p. 173)

Kvale (1984) has identified twelve main aspects of the interview situation. A qualitative interview is:

> 1) centered on the interviewee's life-world: 2) seeks to understand the meaning of phenomena in his [or her] life-world; it is 3) qualitative, 4) descriptive, and 5) specific; it is 6) presuppositionless; it is 7) focused on certain themes; it is open for 8) ambiguities, and 9) changes; it depends upon the 10) sensitivity of the interviewer; it takes place in 11) an interpersonal interaction, and it may be 12) a positive experience. (p. 174)

In this study, I focused on how girls spoke about elementary science and specifically about hands-on experience. The initial interviews contained open-ended questions such as, What is it like to be a student in your science class? Can anyone tell of some experiences you had in science this year that stood out in your mind? and What does school science mean to you?. The questions resulted in the girls speaking of the meanings and nature of science in their lives. From their words I was able to focus on themes that I discussed with them in subsequent interviews.

When Kvale (1984) speaks of being presuppositionless, he does not mean that the interviewer has to attain a state where she brings nothing to the interview but a blank mind. Instead, he means that we should not come with ready-made categories and schemes of interpretations but, rather, a curiosity and sensitivity to any new and unexpected phenomena that may be spoken of. The interviewer should be "critical to his [or her] own presuppositions and hypotheses during the interview. Here presuppositionlessness thus also implies for the interviewer a critical consciousness of his [or her] own presuppositions"

(p. 176).

During the interviews, I found that I had to change and expand my prior thoughts on how children experience and describe school science. When I mentioned my ideas to the girls, they would also speak of how their reflections on the interviews meant that science was no longer the same to them as it was before. In traditional research methodologies, an "observation should, in principle, be able to be repeated at a later point of time" (Kvale, 1984, p. 177). However, in this study it was not possible to attain total intra-subjectively reproducible data in this sense. Instead of compromising the reliability of the study, this spoke of the dominant human element. Kvale (1984) reasons that "the interviewee cannot repeat the meanings he started with in his first interview, because he has during that interview obtained a new insight in, an increased consciousness of, the theme in focus for the interview" (p. 177). Inevitably, the human element and the contradictions and potential for change that we all carry within us prevent us from some traditional description of reliability.

3. Validity, Reliability, and Generalizability: The last point above notwithstanding, validity and reliability were established in the ongoing process of the investigation as I constantly observed, interpreted, and checked the accuracy of my impressions with the participants. This resulted in an accurate description of the situation followed by my interpretations. The readers, too, are allowed to participate in the determination of

validity "to the extent that the observations cover some matters that they the readers are already familiar with" (Stake & Easley, 1978, p. C:27). Through the use of direct quotes, and the girls' confirmation of interpretations, I have tried to present a reliable and valid reflection of school science as the girls experienced it.

This perspective of reliability and validity is in contrast to that used in empirical-analytical studies. In those investigations, "reliability refers to the extent to which studies can be replicated" (LeCompte & Goetz, 1982, p. 35). "Validity, on the other hand, concerns the meaning and meaningfulness of the data collected and instrumentation employed" (Patton, 1975, p. 35). It should not be concluded therefore, that these studies are of marginal benefit to educational research: "human behavior is never static, [and]no study can be replicated exactly, regardless of the methods and designs employed" (LeCompte & Goetz, 1982, p. 35). Patton (1975) claims that the result is that the "alternative paradigm emphasizes validity" (p. 18). Benson (1984) argues that an alternate definition of reliability should be used in which it is "understood to mean that descriptions and interpretations accurately and consistently reflect the situations as the participants experience them" (p. 10). In this way, there is a blending of reliability and validity so that each acts synergistically on the other. For this study, Benson's alternate definition of reliability is most appropriate.

Therefore, validity and reliability are achieved through the

data collection and analytical techniques that are employed in this study. By going to the natural setting, and not a contrived one, by using informant interviewing which is less abstract than an instrument, and by involving the participants in the interpretations I made, I was able to present a description and interpretation of the situation that allows me, the girls, and the reader to participate in the determination of study validity and reliability.

The small number of girls in this study limits generalizability in the traditional sense. Instead, generalizability depends on the degree to which the reader can relate to what is described, remove it from context, and interpret it in terms of his or her own life experiences. Stake and Easley (1978) speak of the naturalistic generalizability of their case studies.

> We looked for a kind of generalizability based on deep understanding of phenomena which increases one's opportunity to recognize similarity and analogy. Each case study depends on this kind of generality. It depends on extending the reader's existing apprehension of experience through new vicarious experience. The general then is a very personal general. (p. C:26)

In this way, if student comments, and discussion of themes can be translated to the reader's situation and result in an extension of understanding, then generalization has taken place. The value to educators of this kind of generalizability is that as readers, they are part of the decision making process and will be able to make a personal judgment about its utility. This is in contrast to empirical-analytical studies where value is expressed in statistical terms and the reader is excluded from the hidden

subjective decisions which also underlie such studies.

B) Field Experience Format

An important field consideration was the amount of time which is allotted to science in the Alberta Elementary Science Curriculum Guide. At the grade six level, 100 minutes per week is recommended. The classroom in which this case study was undertaken scheduled science during the following two class periods:

Tuesday: 10:30 a.m. - 11:30 a.m.

Wednesday: 11:30 a.m. - 12 noon

This meant that I would be doing my classroom observations and interviews in the condensed time period of two consecutive days each week. The advantage was that once these two days were over, I then had a significant amount of time to transcribe my audio tapes and reflect upon the interviews. One disadvantage was that it seemed like a rushed experience and I had doubts as to whether I could record all that I saw and heard.

In total, I observed 360 minutes of science lessons over the period of March 15 through May 6, 1985. During those weeks I carried out three group interviews with the girls, twenty two individual interviews, sixteen validated interview interpretations, and one teacher interview (see Appendix 1 for detailed time schedule).

To get a general feeling for the classroom and to provide me with the time to do a description of the classroom, I sat in on the language arts period that preceded the science class on

Tuesday, April 2. This account provided insight into the physical restrictions of teaching a hands-on activity program, forms of control over student behavior, and general class organization.

During the field experience, the following procedural activities and time line were followed.

1. Ethnographic Recording of Classroom Description, Observations, Lesson Material and Interactions: This took the form of written field notes in my daily journal. These data provided a valuable source of information about the science lesson, verbal interactions, and classroom events. This material was incorporated into the interviews as I sought clarification from the girls as to how they had 'seen' the interactions I recorded. It also provided a base for my interview with the teacher.

2. Group Interviews with the Girls: I began by audio taping two group interviews. During the first interview I spent time in the administrative tasks of explaining the procedures of the study, answering questions as to how the girls were chosen, and outlining various ethical concerns. This interview contained science questions of a very general nature in the hope that I would be able to get an overall perspective of how science was for them.

The second interview explored some of the comments that they had made on the previous occasion. When combined with my classroom observations, these group interviews provided the starting point for the individual interviews.

A final group interview was held on April 30 in which we discussed the eventual write-up, and the girls' reaction to participating, and explored some general hypotheses I had identified from the completed transcripts.

3. Individual Interviews with the Girls: Each girl was interviewed three or four times on an individual basis. Each interview was approximately twenty minutes long and was based upon their reaction to the science lesson being taught, general opinions about science, and the clarification of previous comments they had made (see Appendix 2).

4. Validation of Interview Interpretations: After each individual interview, with the exception of those in the final week, I transcribed my audio tapes and attempted to do an interpretation of the commentary (see Appendix 3).

This interpretation was then given to the girls during their next interview period and they were encouraged to make any changes that would render it an accurate reflection of their experiences in and meanings of school science. Although I tried to include inferences, and analysis of the interview transcripts in these interpretations, they turned out to be little more than interview summaries. It was difficult to know how to avoid this. Eventually, I came to the conclusion that interpretations can best be made only when one has begun to understand the classroom overall, and to feel a degree of familiarity for the classroom and participants. As a result, these early interpretations were of marginal benefit to the final analysis.

5. Daily Journal of my Personal Opinions and Introspections: This was written in the same notebook as my observations of the classroom and included reactions to informants, classroom observations, and the emotions I experienced during my research. It proved to be a valuable source of information, and some of my comments are included verbatim in this study (see Appendix 4).

6. Teacher Interview: I interviewed the teacher at the end of my study on May 6, 1985. The rationale for this timing was that I wanted to observe the classroom experiences as they happened without constantly trying to interpret them according to what the teacher may have previously outlined to me.

During this interview I inquired about his views on elementary science in the curriculum, his teaching strategies, and his reaction to this study. A transcript of the interview is included in Appendix 5.

Also, the teacher read an early draft of this study and was given the opportunity to react to its contents.

IV RESEARCH SETTING

The decision to explore my questions by using a case study framework necessitated identifying a specific bounded system and group of girls to which I could direct my attention.

A) Choosing the Classroom

An application providing a description of this research project was directed to the Science Supervisor of an Alberta school system. This application form asked the Supervisor to recommend a "more or less 'typical' grade six classroom in which science is taught regularly."

'Typical' is a somewhat ambiguous term which is open to perhaps as many meanings as there are people. Quite likely, the Science Supervisor's idea of 'typical' isn't precisely my idea of 'typical', if indeed 'typical' even exists in the world of elementary science classrooms. Given the results of the Science Council of Canada report, one must wonder if a 'typical' elementary classroom is one in which science is taught at all. However, the extent to which the classroom that is chosen is 'typical' should allow me to reasonably assume that some of what I see may also be happening in other classrooms.

I requested a grade six level classroom for this study for three reasons. Grade six students generally have a larger vocabulary and are more verbally articulate which would be helpful in interviewing. As well, grade six students have had more experience in elementary school science and thus are likely

to have a wider perspective and more broadly based opinions than younger children. Finally, research literature seems to indicate that, in general, girls experience a decline in positive attitudes toward science as they near adolescence. Exploring how it is for girls as they approach junior high might help us to understand what is happening here.

B) Choosing the Participants

On Friday, March 15 I had my first meeting with Mr. B, the classroom teacher who agreed to participate in this study. The purpose of this meeting was to introduce myself, inform him of the nature of this study, and choose the participants. During our discussion, I gave Mr. B a copy of my thesis proposal, the request form that had been sent to the school system, and the permission letter that was to be distributed to the girls (see Appendix 6). I reviewed the research design with him and outlined the student interviews, classroom observation, validation procedures, and provision for teacher input. I also encouraged him to feel free to add any input to the study and even to provide written comments to be included in the study.

After I finished my explanation of the study, we proceeded to choose six girls from Mr. B's homeroom who were verbally articulate and who encompassed a range of academic ability. Mr. B however, didn't have girls who were low in ability and we ended up choosing six girls who had average to above average capabilities as judged by Mr. B. The pseudonyms that the girls chose for themselves were Jenny, Melissa, Jane, Alison, Liona,

and Sandy. All of the girls were eleven years old when the study began, except for Liona who was twelve.

This initial meeting with the teacher, and my subsequent selection of and introduction to the girls, provided important insights into their personalities, and how they see the world, and exposed a significant study theme. Before continuing on to outline the setting of this study, I will recount these important first moments.

1. We're Going to be in a Book?: After his selection of potential participants, Mr. B gave me a brief tour of the school before he was summoned back to his class when the afternoon bell rang.

> ... I drifted back along the hall as the children came in from the playground. Mr. B spoke to his class for a few minutes and asked the girls to go to the classroom door. Liona was absent, so I took the other five with me to one of the phys-ed offices to talk. As we walked down the hall they asked me if I was the nurse. When I assured them that I wasn't, they were quite relieved as they had recently been given some needles and they didn't want any more.

Later in the course of this study, Alison spoke of this initial selection with the following words:

> Well, when we first came here, I don't usually get called, I don't get picked for stuff much. And like, so lots of us kids, the girls, we thought we were in trouble 'cause when we get in trouble the principal calls you out to talk to you. And we were kind of scared. And then we saw you and we thought that you don't get in trouble with you, you don't work in our school, so we thought this was a special project or something.

We walked down the hall together and went into a deserted physical-education office. I introduced myself as a student

researcher from university and explained that I was interested in learning how grade six girls experienced science in school and what they had to say about it. It was difficult to explain what a thesis was so I used the analogy of a long essay or book. This brought on great excitement and comments from the girls.

"You mean we're going to be in a book?"
"Wow, I've never been in a book before!"
"I can just see my name in a book!"

Once they had calmed down, I explained how participants in human research were always protected through the use of substitute names. This would give them privacy and anonymity when the study was read by other interested parties. There was some disappointment when I announced that guideline.

During the first group interview, Jenny again brought up the subject of substitute names.

*11. Jenny: When you write this, like you know how you're not going to use our names? Why? Like, I don't mind if you use my name.

12. Int.: It's just to give you privacy. Whenever we do research from the university they give us a big book called a book of ethics which is to do with rules on how to treat people. And when you go out to interview people they say that one of the rules is to give people privacy.

13. Jenny: Yah, well, I don't mind if you use my name.

I promised the girls that I would give them a copy of the study when it was completed in August. They replied enthusiastically. I then informed the girls that I would be tape recording a series of interviews in which I would ask them about

*refers to line number from interview transcript

the experiences they have in school science. One girl asked me if I would be questioning them about their whole year of work in science and I replied that although there might be some general questions, it would mostly be about what they were taking right now. As soon as I uttered that statement the girls chorused, "Oh no, it's electricity!" They groaned, put their hands over their mouths and looked upwards.

My immediate reaction to this was that it was an example of how girls feel alienated from science topics which are not biological. It has been suggested in some research literature that areas of physics and chemistry have a masculine image. For example, if a girl elects to take a science course in high school, she is most likely to choose biology (British Columbia Science Assessment, 1978; National Assessment of Educational Progress, 1970, 1977, 1978). Also, Erickson and Erickson (1984) reported that in the British Columbia Science Assessment of 1978, sex related achievement differences in biology were very small, but the difference increased as they moved from chemistry to earth/space science to physics.

I felt as if I had come across my first insight into how children, and perhaps girls especially, felt about science. Maybe these girls felt they could not identify with this science topic because of stereotypes attached to it. But, when I discussed this vignette with the girls during the initial interviews, I learned they each had their own interpretation that did not necessarily agree with mine.

59. Int.: Do you know why?

60. Melissa: Well, at the beginning of the chapter, well, it was kind of boring. And then when we started doing experiments, it got more interesting.

61. Int.: So you groaned because you thought I would be asking you boring questions on electricity?

62. Melissa: Well, we thought you would be asking us questions and we'd feel bad if we answered boring answers.

15. Int.: ... Do you know why everyone groaned once they said, 'Electricity?'

16. Alison: Well, because most people don't like science. Science isn't one of their better marks. And like most people don't like science. Sometimes they think science is boring.

17. Int.: Did you groan, can you remember?

18. Alison: I don't think I did. I always liked science.

These two conversations combined to uncover one of the underlying themes that ran through this study. It was obvious from these comments that each girl was interpreting the world around her in a unique way. An action that I had interpreted as an unanimous rejection of electricity as a topic in science was not that way at all. Instead, Melissa had related my comment to her desire to please, and Alison to academic attainment in that subject area. I decided to be more cautious and seek clarification from the girls about apparent connections to related research literature.

C) The Setting

Evergreen School is located in a large western Canadian city. It is surrounded on four sides by low income and middle class housing. The school contains kindergarten through grade six with approximately 400-450 students in attendance. Eighteen classes are in operation and these are located in a combination of attached portables and main building classrooms.

The Division One classrooms are clustered in a group of portables in the southwest corner of the school. They are carpeted, connected to a main hallway and appear well built and bright. Coats hang in the hallway and there is an air of organization and industry. The school gymnasium is located to the north of these portables.

The southeast wing of the school has a main hallway with another cluster of portables joining onto it which apparently were "hauled back from the dump and attached to the school." They are smaller than the Division One portables and the outside light clearly shines under the emergency exit doors of each classroom. During the winter it is possible to get a cold wind blowing under the door and when the furnaces turn on to warm the children, "the floor shakes."

The main building is comprised of more classrooms, the staffroom, and assorted offices. Mr. B's classroom is located in this area as is the other grade six classroom. He has twenty four students in his homeroom of which approximately 25% are from single parent homes.

A row of shelves runs along the east side of the room. Piled on top of these shelves are an assortment of sports bags and knapsacks. These belong to the students and are stored on the shelves because the school contains no lockers. A small window is located above a portion of the shelves and is bordered by a box of crosswalk signs and belts. The shelves are used for storing textbooks and various instructional materials.

The teacher's desk is in the northeast corner of the room facing the backs of the students. Located next to this desk is a free-standing shelf unit and an Apple II Computer. The children take turns using the computer by following a checklist of their names which is written on a side chalkboard.

The walls are covered by an assortment of posters and displays. One bulletin board contains a birthday chart with the children's names printed on it. It is printed in French and has the title Le Mois et les Saisons. A variety of student-made collages are lined up on the wall above the shelves. They are thematic in nature and contain the phrases: A friend is ...; or A parent is ... . Another bulletin board has an arithmetic skills chart and a two-sided sign saying 'Quiet' on one side and 'Quiet Talk' on the other. During the course of this study, the teacher was observed to use this sign to indicate to the children the preferred noise level of the classroom. A third bulletin board contains the Problem of the Week and a fourth, a display on how to solve math problems. A free-standing chalkboard summarizing homework in each subject area leans against the front wall.

Mr. B's classroom gives the general impression of being bright, due to the yellow walls, white panelled ceiling, and fluorescent lighting. But there is also a sense of crowding. The sloped desks, crowded shelves, lack of plumbing, and restricted space could all serve to influence the amount of activity that could be encouraged, especially in a science program.

D) The Teachers

Mr. B alternates teaching science every other week with a science facilitator named Mrs. T. The school administration requested Mrs. T's services at the beginning of the school year when they began a new science textbook series (Addison-Wesley Science).

1. Mr. B: This teacher trained at university to be a secondary English teacher. Because he took the secondary route, he did not study any elementary curriculum and instruction courses. However, he did take a first year biology and chemistry course at university before switching his major to English. He is now in his fourteenth year of teaching.

Mr. B likes science as a subject area and spends some time outside of school reading science books, and carrying out nature studies at home with his son. He also intends to visit some of the science-related centers which are located in the city area.

Mr. B has mixed feelings about teaching elementary science. Although he enjoys the science content and sees the value of an inquiry approach, he finds that the preparation for class

activities can be overwhelming. The collecting of materials for science class and the need for practicing the activity ahead of time impinge on an already full day. Also, an activity approach to science necessitates a class atmosphere where children can work and speak with each other. Mr. B feels, that for most teachers, these noisier types of classroom activities are disconcerting as it gives the teacher the feeling that the class is out of control. However, Mr. B has found that if he gives his class a chance to do some hands-on science activities, it is easier to get them to do their desk work because they have had a break from it.

Mr. B speaks enthusiastically of the help that has been provided by the science facilitator. She has been invaluable in providing a role model of teaching strategies in addition to giving him practical suggestions as to how to group children and set up activities.

2. Mrs. T: This teacher is a science facilitator with the local school board. At Evergreen School she assists at the grade four and six levels.

At the beginning of the school year, Mr. B was provided with a set of lesson plans which coincided with the Addison-Wesley Science textbook series. Mrs. T completes one of these lessons with the class and during the following week, Mr. B must do the follow-up. In this way, they are tied to a strict time schedule as they cover the prepared lesson plans.

When Mrs. T arrives for science class she brings a box full

of science materials with her. These materials have been collected the previous Friday at the school district's teaching center. Mrs. T must then carry these materials from school to school as she assists teachers throughout the system.

Mr. B feels that his students are very receptive to the kind of science lessons that Mrs. T presents. Not only do they enjoy the activities that she encourages, but Mr. B thinks that it is a positive experience for the students to interact with a variety of teachers.

The sex of the science teacher is a topic which has been discussed in some recent research literature as being influential upon how girls view science as a subject area in school. Because these girls had science teachers of both sexes, I felt it was important to question whether this made a difference for them.

3. It's Just the Way They Operate: When I questioned the girls about whether the sex of the teacher made any difference to them they all answered negatively and then proceeded to detail what really mattered.

40. Jane: ... It's just the way they operate, the way they explain it, and the way they ask questions and stuff like that, that really makes a difference.

32. Jenny: ... Well, it's the person's personality.

34. Jenny: It's just how they help you along and how they act, you know.

51. Sandy: ... But, I don't think there's really a difference.

53. Sandy: ... it depends more on what they know and what their teaching is than whether they're a guy or a girl.

54. Sandy: Well, I don't really find a difference, but I like it better when they actually let you take part ... But, [when] someone in our class, a fellow student, is doing something, it makes a difference. It's more what you get to do rather than who the teacher is.

34. Melissa: No, it doesn't matter 'cause like, lots, the men know as much as the ladies do sometimes.

26. Alison: Well, there isn't much difference ... There's not much difference. Except the men are sometimes a little stricter.

48. Liona: [What is important is] that you understand what they are talking about and you can see the problems in it and it can help decide what you want to be.

For the girls, teaching strategies, amount of student participation, teacher personality, and the ability of the teacher to present the science material took precedence over the sex of the teacher.

In research literature, the influence of female role models in science is at best controversial. Some researchers suggest that an apparent lack of female role models influences girls to avoid science classes and careers (Button & Brown, 1980). Other researchers state that girls do not do any better with female teachers or where a larger proportion of science students are

female (Kelly, 1981). Hageman and Gladding (1983) tend to straddle these two extremes when they state that "whereas role models may not encourage children to consider an occupation, they do make explorations possible" (p. 284).

Clearly, there is a wide range of opinions on the influence of role models. Perhaps it suggests that it depends on the actual person who is providing the role model, or that there are other factors which influence girls that may outweigh the sex of the science teacher. The grade six girls in this study, however, were unanimous in their feeling that other factors were more important than their science teacher's sex.

V EXPERIENCING SCHOOL SCIENCE: HANDS-ON SCIENCE ACTIVITIES

The different science activities which transpired in the classroom and the percentage of time accorded to each are outlined in Table 1. This chapter will focus on the girls' experience of hands-on activities which are defined as those which involve the children in the manipulation of concrete learning materials. This may entail using science equipment such as microscopes, constructing apparatus such as model turbines, or manipulating materials such as doorbells and dry cells for the purpose of demonstrating textbook lessons.

My prior life experiences in presenting this kind of a science program predisposed me to the opinion that this is one of the kinds of science activity that most resembles life. It seems that during these times students are able to begin to wonder, enthusiastically participate, and become responsible for their learning. This cycle of wonder, action, and reflection perhaps parallels our fundamental relationship with the world. When free to interact with a question which personally captivates us, we are internally motivated to pursue an answer and seek fulfillment. In elementary science this cycle may be interrupted by numerous external forces, but perhaps hands-on activities provide an environment where we can most closely approach a similarity between school science and everyday life. I wish to approach this supposition sensitive to comments from the girls which may support or contradict it, in an effort to discern whether the girls are also drawn to this interconnection between hands-on

Table 1

Science Activities Expressed as a Percent of Total Time

Type of Science Activity	Approximate % of Total Science Time
Teacher Directed Activities	50
-asking review questions, overhead questions, filmstrip questions	
-teacher demonstration	
-teacher reading from text, giving directions	
-teacher showing a film	
-students read from text, class discussion	
Desk Work and Written Exercises	30
-doing worksheets, text questions, teacher generated questions	
-marking worksheets, questions	
-drawing diagrams	
-copying notes	
Hands-On Student Activities	10[a]
-working on hands-on activities in groups or individually	
Exams	10
-unit exams	

[a]The teacher estimates that when the entire year is taken into consideration, this catenory of activities involves about 20% of science class time.

activities and how they live their lives.

As the girls elaborated on their experiences of hands-on activities, it became apparent that although each was a unique individual, they nevertheless held some shared meanings of school science. These mutual themes became the headings I have used in the following pages; when combined with discrete comments, they provide the framework for a discussion about how the girls experience hands-on activities.

A) Active Participation

During the interviews the girls were unanimous in their approval of hands-on science activities.

57. Melissa: ... I find it interesting because you do lots of different things.

75. Sandy: I think it's fun and interesting because it's fun to use all those neat things.

73. Sandy: ... it's fun to do stuff ...

This endorsement of hands-on activities suggests that the girls' enthusiasm is an outgrowth of the opportunity to actively participate in the learning. But, what is it about this 'doing', this active participation, that brings about such affinity? Could it be that concrete manipulation stimulates a sense of wonder about things, or is it simply a respite from more sedentary pursuits? Does it make science learning easier and more enjoyable, or is it

just time that may be perceived as wasted? Perhaps a detailed exploration of the themes which emerged from the girls comments about enjoying hands-on activities will help us to understand their experience.

The preference to participate was recounted by the girls in several of their comments.

77. Jane: ... I'd rather look at it myself and find out what it does without a teacher actually having to tell me.

78. Alison: I like to do the experiment myself ... rather than see the teacher do it.

55. Sandy: ... I like it better when they actually let you take part.

Although their enrollment in school, physical presence in the classroom, and completion of daily assignments might already suggest participation, it seems that for the girls this much is only marginal in nature. In their words, participation requires an active involvement which extends beyond watching and listening.

For these girls, participation involves a state of independence where they experience the activity first-hand. No longer is it being demonstrated or explained by the teacher, but the learning is taken onto themselves and possessed by them alone. They become personally responsible for the outcome and must depend on their own creativity to complete the activity and gain understanding. But, how can such an independent search be described

as participation? Perhaps in these statements the girls are not explicitly referring to participating with people, but with the learning. This participation with ideas is seen as a personal undertaking and in that sense, something they would rather achieve on their own.

Working independently may seem unusual in that it sounds more difficult when compared with watching a teacher and being provided with the answer. Why bother going through the challenge and perhaps frustration of hands-on activities, when listening to the instructor or reading a textbook seems less effort? Perhaps one explanation lies in the intellectual thrill associated with active participation, a sense of conquest and confidence that can only be gained through accepting a personal challenge, wrestling with dilemma, making choices, and experiencing accomplishment. Perhaps other teaching strategies short circuit this potential area of pleasure with the result that children enthusiastically welcome opportunities they see as allowing for this delight.

Additionally, Donaldson (1978) may provide partial explanation when she emphasizes that our relationship to the world as a whole is one of active participation. "We do not just sit and wait for the world to impinge on us. We try actively to interpret it, to make sense of it. We grapple with it, we construe it intellectually, we represent it to ourselves" (p. 67). Perhaps it is inherent within us to reach out and participate with the world we share. Anyone who has observed young children during the first few years of life will attest to the compulsion from within

which seems to drive children to explore every facet of the environment whether the parents want them to or not. When the girls are in science class, it seems only natural that they would want to re-live the sense of independence and success of this primary mode of learning about the world that perhaps resides within us throughout life.

Other authors have elaborated on the importance of active participation in learning and linked it to an essential communion human beings share with this planet. Bronowski (1978) suggests "we must grasp that we are all a part of the world we observe" (p. 102). Capra (1982) adds "we can never speak about nature without, at the same time, speaking about ourselves" (p. 87). Maybe these comments can extend our understanding of the girls preference for active participation. Perhaps participation is fundamental not only to learning about the world and providing a foundation for "wonderful ideas" (Duckworth, 1974, p. 265), but also describes our inevitable stance in the world. We are not isolated entities but define the world through our interconnection and relationship with it. We do not stand alone but are constantly reaching out to other things in our search for personal meaning. Maybe when the girls state preferences for active personal participation in school science, they are alluding to this essential human participation with the world that underlies life itself. Through this participation we discover both the world and our Selves while journeying towards becoming more fully human.

As the girls described their experiences with hands-on

activities, they outlined a number of factors which perhaps disclose their personal understanding of participation. These were: taking their own time; thinking in their own way; socializing; communicating; predicting; and gaining confidence. Maybe these factors suggest that the girls see participation as an opportunity to direct their own learning and pursue science in a personal way, a way that mirrors the pursuit of knowledge in their everyday lives.

1. You Take Your Own Time:

81. Int.: How come [this lesson] was one of your favorites?

82. Liona: ... the other experiments, the teacher always does it for us. And now, we did it all by ourselves.

86. Liona: ... When you do it, you take your own time.

108. Jenny: I'd rather have a lot more time and get it right than just having a bit of time.

It seems ironic that the girls speak of taking their own time when, in fact, the length of the science period is dictated by the class timetable. Perhaps one interpretation lies in the idea that school time is less obtrusive during hands-on activities. Instead of doing tasks within a shorter time frame where a teacher may play a prominent role, they are given the entire science period, or a good portion of it, and instructed to complete the activity within that class. This may give the students a perception of flexibility within the larger time frame, to use

time according to a pace which suits their personal skill and understanding level.

Lippitz (1983) uses Langeveld's conception of time to further explore this experience.

> For Langeveld, time is not primarily a cognitive structure, but rather a structure of the lifeworld. Time is embedded in experiences and lived experiences in such a manner that it is not explicitly recognized as such. Children as well as adults live <u>in</u> and <u>with</u> it. Time runs through their biography and orders their communal living. (p. 175)

Perhaps as the girls participate in hands-on activities they experience personal lived-time instead of imposed clock-time. During lived-time, they encounter a different flow of time, and a personal duration which they discern as their own. This lived-time does not follow regimented clock-time but ebbs and flows during different life experiences. Encounters with lived-time are reflected in comments we may make during enjoyable experiences such as 'time just flew by' or during periods of boredom when 'time crawls'. Although both experiences might have been of equal length as measured by clock-time, we have experienced them differently according to our own lived-time. Perhaps this realization of lived-time is what the girls mean when they speak of taking their 'own time' during hands-on activities.

Further, during our time in school and everyday life, we must live within time restrictions, deadlines, and the ultimate limitation of our life span. This strain between imposed clock-time and lived-time creates a tension of time. We are constantly faced with trying to order our personal flow of time

to the larger imposed time structure. Within this frame of imposed time there are moments when we talk about 'taking our time' or 'needing more time', and frequently we speak of the importance of learning at our own rate. Perhaps these experiences suggest the tension of time that we all feel during life, and maybe when the girls are participating in hands-on activities this tension fades to the background and they are able to proceed at some personal pace characteristic of their lived-time.

2. In Your Own Way: Implicit within the girls' comments on active participation and time is the idea that when granted increased independence, they are able to personalize the learning and possibly enhance their understanding.

32. Liona: ... the teacher always does [the experiments] for us. And now, we did it all by ourselves.

39. Jenny: ... it helps to figure it out for yourself ... You can think about it in your own way.

37. Jenny: ... to be able to do it on your own I think you understand it more because you can figure out the way you want ... there shouldn't be one single way to have to do it ... everyone has their own way of doing things.

Although the textbook program introduces the activity, suggests materials, and discusses possible outcomes, the girls speak of taking this instruction and understanding and discharging it in their own way. Perhaps these observations are interconnected with the previous discussion on active participation and lived-time.

Maybe hands-on activities allow active participation with the learning according to some personal sense of lived-time, and with this inevitable inclusion of themselves, they further employ a personal sense-making which individualizes the learning. Although the framework of the activity is supplied from an external source, they appropriate that information and personalize it in some unique way.

Later on in the study, Sandy referred to this personal sense-making which, in her opinion, each student experiences regardless of whether or not they are participating in hands-on activities.

> 196. Sandy: Like, the way we get our homework done and stuff. We don't always want to do it the way [the textbook or teacher] says. We've got our own way of doing it.

These stirrings of autonomy seem predominately connected to hands-on activities although Sandy suggests this personal sense-making extends to and possibly permeates other school activities. Perhaps students always learn in their own way, but they feel it is encouraged or given legitimacy during participation in hands-on activities. This may suggest that true individualization of learning is not done by teachers wielding a plethora of lesson plans, scope and sequence charts, and standardized achievement tests, but by the child making the learning her own through active participation, experiencing the personal freedom of lived-time, and confident of the propriety of personal sense-making.

3. You Get to Communicate: Previous quotations have suggested that active participation is enthusiastically endorsed by the girls because they get to experience a state of independence where they participate with the learning by themselves. But, this participation with learning does not necessarily preclude a solitary existence devoid of contact with other human beings. Instead, the girls saw personal participation with the learning as an experience that could be enhanced through socialization with their peers.

36. Sandy: It was fun because you got to get up from your desk and move around and you could socialize with your friends while you're pouring the water and the other one's holding the turbine.

47. Int.: ... Not only is it fun, but you also get to ...

48. Jane: Communicate.

49. Int.: ... with your friends a bit?

50. Jane: (nods yes)

45. Jenny: ... I like the ones we can do on our own but we still have someone to ask questions with.

47. Jenny: ... you can talk about what you think it should be like ... and you can understand it more 'cause you have someone to talk to. Someone to help you.

Although they speak of enjoying personal, individual absorption in hands-on activities, learning at their own pace, and learning in their own way, these additional comments suggest

that it does not mean a retreat from the world. Instead, the girls welcome the opportunity not only to creatively grapple with problems, but to seek out others who would lend support, encouragement, assistance, and illumination. Perhaps the girls see hands-on activities as an opportunity not only to participate actively in the world, but also with it, cooperating and sharing with others.

These quotations may also suggest a connection between communication, socialization, and learning. Sund and Bybee (1973) recognized this link and stressed that "Piaget believes social interaction is an important aspect of learning and thus should be pursued for a considerable amount of time in elementary school" (p. 63). Furthermore, Bruner (1971) observed the value of this socialization and commented:

> A community is a powerful force for effective learning. Students, when encouraged, are tremendously helpful to each other. They are like a cell, a revolutionary cell. It is the cell in which mutual learning and instruction can occur, a unit within a classroom with its own sense of compassion and responsibility for its members. (p. 21)

But, what is it about communicating with others, and the sharing of experiences which the girls see as enhancing their enjoyment and perhaps learning, during active participation? Whitney (1983), studying the lives of a group of children in an elementary social studies classroom, perhaps offers an analogy to hands-on experiences when he discusses his students' preference for role-playing. "When role-playing was introduced in social studies it was eagerly accepted because it had always been a part of their own time. Their play constantly involved

'playing parts' and this extension into the school curriculum was just a bonus" (p. 181). Perhaps the girls have preferences for communication, mutual helping, and sharing with others because it has always been part of their lives outside of school. Maybe as young children they experienced the challenge of discovering the world on their own, but also sought out parents and other children for guidance and advice. Inevitably, we seem to be social animals. Our human ability to speak a language and express our thoughts only add to our social character and motivate us towards greater interaction with others. The freedom to explore, participate, and communicate is a way of living in the world that feels like home.

This interaction, participation, communication, and social character of human life seems to parallel the nature of science activity. Nadeau and Desautels (1984) state that "science is preeminently a social activity" (p. 39). Equally, "scientific activity is not carried out in isolation" (p. 39). And Thomas (1974) suggests that "there is nothing so social, so communal, so interdependent [as science] " (p. 118). Therefore, perhaps when the girls speak of their preference for socializing they are not only speaking of an extension of their everyday lives into science, but are describing how science may be characteristic of how they naturally live life. Both involve an active reaching out to the world, an exertion toward personal sense-making, and mutual association with others. Bronowski (1978) reasons that "human life is social life, and there is no science which is not in some part a social science" (p. 99).

Perhaps hands-on activities provide an environment which encourages this human vision of science, a vision which illuminates its social character, subjectivity, and interconnectedness with the world. Through hands-on activities and the participation they encourage, the girls perhaps intuitively experience a coming together of science and life.

4. You Get to Predict: Prior to completing some hands-on activities, the girls may be encouraged by the teacher to advance a prediction about the outcome. They commented that this enhances the interest level of the activity and challenges them to be creatively involved in the learning.

28. Jane: ... and I think that's pretty neat because you try and think of what's going to happen before it happens.

58. Alison: ... and it's pretty interesting when you're not sure about stuff.

16. Sandy: Well, I think it's kind of fun ... you go 'Well, maybe it's this' and then you guess, and [soon] you know ...

But what is it about declaring in advance, or foretelling on the basis of observation or experience, which results in the girls describing it as 'neat', 'interesting', and 'fun'? Maybe one reason is the intellectual challenge and pleasure which was previously discussed as interconnected with the girls' preference for active participation. Another possibility is that life itself is always directed toward a future. In our everyday life we

constantly anticipate the future and try to plan our lives accordingly. We predict social, economic, and political trends and attempt to make decisions about career, family, and finances. Perhaps when this characteristic of human life is incorporated into the school science program, the girls are drawn to it because it is similar to an activity that is already part of their lives. They already anticipate weekend activities, summer holidays, future careers, and eventual success in life. Therefore, to make a prediction about the outcome of a science activity, parallels something with which they are already familiar.

Donaldson (1978) concurs that involvement with the world enables us to "build up ... a kind of system of inner representations, the value of which is to help us to anticipate events and be ready to deal with them" (p. 67). Perhaps by taking part in hands-on activities, the girls begin to construct their own reality in a personal way which allows them to subsequently extend this information to other life situations and make predictions about future events.

Additionally, perhaps predictions reveal the tentative nature of both science and life. We can only make the best decisions possible based upon past experiences and subsequent observations. There are no guarantees that we will always be right and successful. Life and science present a challenge to our creativity, ability to adapt, and wisdom to accept outcomes regardless of whether they were correctly anticipated. Perhaps encouraging prediction

in science class not only parallels a characteristic activity of science, but is constitutive of life itself and the tentativeness with which we all walk upon this earth.

5. It Feels Kind of Neat: Melissa spoke of how persistence with hands-on activities gave her an increased sense of confidence and personal delight.

> 24. Melissa: ... sometimes you don't really understand what they're asking you to do ... But, then when I do get it, it feels kind of neat to see different things and stuff.

> 28. Melissa: Well, when we do experiments ... and I do it okay, and it turns out good, then I'm happy.

Implicit within these comments is the acceptance of those times in hands-on activities when mistakes are made and when the girls must endure error. At these times, the girls have to rethink the activity, select an alternate method, and try again. This process of persisting until we succeed is a necessary part of science and life. To quit and forsake the problem does not result in the gain of knowledge we seek. Although we can often learn from failure itself and 'negative' results, it is the compulsion to recover from our defeats, creatively try again, and persist towards new learning which makes this experience characteristic of science and inherent to life.

Donaldson (1978) also sees persistence and the enduring of error as intrinsic to life. "Education should aim to encourage the readiness to come to grips with incongruity and even to seek

it out in a positive fashion, enjoying challenge. Equally, it should aim to discourage defense and withdrawal" (p. 118). By experiencing moments in school when we are perplexed or have failed, the recognition of our error, selection of alternative strategies, and eventual success leave us in a stronger position. Donaldson (1978) reasons that as long as we believe we are always right, there is no hope of inner change.

The sense of accomplishment which develops from persistence and success seems to be identified with hands-on activities. The girls experience a personal satisfaction and increased confidence in themselves that they don't readily identify with other science activities. When the girls are personally involved in and responsible for the learning, they see subsequent achievement as also their own. Instead of relying on external rewards such as marks or approval, they experience intrinsic satisfaction with personal victory and enhanced competency.

B) Implications for Understanding

As we see in the preceding discussion, the girls indicated that when they have the time and freedom to actively participate, work at their own rate, learn in their own way, communicate, predict, and grow in confidence, their understanding of science is heightened. Perhaps this suggests that understanding is proportional to the degree to which they can personally participate in the curriculum. Further, the processes of learning and experiences of life that the girls associate with science

seem similar to those used by all human beings to explore the world in which we inevitably participate. Through acting upon our environment we are able to expand our horizons, feel involved, and increase our knowledge of our place within creation.

The girls were unanimous that hands-on science activities increased their understanding of the lesson.

45. Jenny: I understood it more because of all the experiments ... Experiments explain it more and you can understand it better.

75. Sandy: ... you learn a lot when you do it.

22. Alison: ... with more equipment, you learn more.

26. Liona: ... if there's some parts of the experiment [the teacher] can't explain, you could just see it.

Clearly, personal participation and access to science materials were seen as key to enhancing learning and understanding. Heffernan (1973) also recognized how understanding is linked to experience when he commented that what a child learns "depends upon [her] experience, because experience is the basis of all learning. A child can learn to know and do only what [she] has access to through experience" (p. 232). Sund and Bybee (1973) concur by using Piagetian learning theory to declare that "involvement is the key to intellectual development, and for the elementary child this includes direct physical manipulation of objects" (p. 63). Alison recognized this bond and wished it

could be maximized through increased student participation.

61. Alison: ... So how will we ever know how to do it if they don't give us a chance?

With this apparent emphasis on the relationship between doing and learning, it seems almost contradictory that the girls should speak of their personal academic achievement in science despite the fact that hands-on activities are not the dominant teaching strategy in the classroom.

9. Jenny: ... there's not many that I don't understand.

14. Sandy: I mostly understand what's going on.

Several suggestions can be advanced to explain this seeming contradiction. Perhaps the girls are able to learn from other science teaching strategies, but in contrast they feel learning is personally enhanced or easier to recall when encountered in a concrete way. Or, maybe their academic proficiency enables them to quickly understand school science to some degree regardless of presentation. In addition, two of the girls spoke of how they perceived learning in science and affinity for that subject as being linked to academic attainment.

98. Jenny: ... I learned more ... Like, I got better grades.

16. Alison: ... most people don't like science. Science isn't one of their better marks.

Maybe these girls feel they 'mostly understand' because their science report card marks are A's and B's. Perhaps students reason they must have understood the concepts because they have the mark to show for it. Maybe this equating of marks with understanding is what Jane implied in the following comment.

28. Jane: ... if you get it right you sort of think. 'Oh, I'm doing good in this subject', so I keep going.

It does not, however, seem clear what the girls mean by learning and understanding. Maybe each student defines these words in her own way depending on her personal interpretation, and previous exposure. Learning might mean memorization and regurgitation, or the gaining of visible skills, or it might mean a deep sense of personal understanding, or the ability to creatively interpret and reapply information to novel situations. Or, maybe students are not confident they even understand what understand means and resort to depending on external sources such as exams and teachers to indicate if they have learned the science lesson. Trempe (1984) argues:

> For students the word 'learn' has a very vague basic meaning, and is essentially intellectual (in that it does not really express a fully conscious experience). It serves as a justification that sounds good, and echoes what students have heard their teachers say many times over. It is not a reason for action grounded in personal experience. (p. 249)

Perhaps teachers do take a narrow view of learning and understanding which our students infer from our comments and opinions, eventually to adopt as their own.

During the previous discussion on participation, one

recurring theme was the opportunity these activities presented for the girls to bring themselves into the learning. Maybe this suggests that learning involves not only numerical achievement, but also the extent to which it becomes personally meaningful. Bybee (1981) concludes:

> We usually equate learning with retention of knowledge and subsequent change in behavior. While this view is accurate, it presents only part of the picture. Learning is cognition plus the degree to which the material holds meaning for the child. What is learned has meaning because it is physically and/or psychologically close to the child. (p. 43)

Despite the numerous interpretations that could be made of the girls' comments on learning and understanding, perhaps we can still say that regardless of how the girls are intrinsically defining these terms, they feel there are times when understanding in science can be enhanced by the presentation of the lesson, and that they learn more through hands-on activities. This area of how children speak of learning and understanding in school science seems to be one which could benefit by further exploration especially in regard to specific science concepts, teaching strategies, and curriculum content.

C) Curriculum Considerations

Although the girls were enthusiastic about active participation and felt it enhanced their learning, they qualified their remarks by stating preferences regarding content. They emphasized that some subject matter which the activities were designed to demonstrate at times seemed remote to their everyday lives.

Perhaps these mixed feelings about some subject matter are in

part due to the use of a textbook program to provide topics of study. The students don't seem to be part of the decision-making process to choose appropriate chapters nor are they allowed to individually pursue science of personal interest. Instead, they are supplied with subject matter which may not seem physically or psychologically close to their lives.

These perceptions of curriculum content seem in contrast to their comments on participating in hands-on activities which emphasized being personally involved with the learning. Perhaps curriculum decisions represent a break in the sequence of student involvement. Maybe they can only be involved when they actually get to do the hands-on activity but remain excluded from the initial decisions of activity topic. The result may be that they enjoy the activity for all the reasons they have already mentioned but their interest is tempered by subject topics which remain unrelated or only partially connected to their everyday lives.

The girls seem to think that science curriculum content should spring not necessarily from a textbook, but from their personal wonder about the world and previous life experiences.

122. Alison: Like, I always wonder about the earth and all that. And I always wonder why that happens ...

They have a view of science which begins in inquisitiveness and a questioning of the environment, an attention to unexplored areas which have the power to beckon them closer. This wonder

does not spring from a vacuum, but builds upon the foundation of the child's previous life experiences. A child cannot wonder about a tree if she has never seen one. She cannot be puzzled over the texture of the bark if she has never had the opportunity to touch it. This personal participation with the world acts as a catalyst for wonder and underlines the necessity for early childhood experiences rich in stimulation and variety, that can be appropriated, included, and expanded upon in the elementary science program. By using these personal experiences as the starting point for active participation in hands-on activities, the child may experience a more complete coming together not only of similar processes involved in science and everyday life, but also how these experiences originate in wonder emerging from personal involvement with the world.

Donaldson (1978) has also observed this wonder in children and agrees that it is not just restricted to science but is natural to all areas of our lives. "We are, by nature, questioners. We approach the world wondering about it, entertaining hypotheses which we are eager to check" (p. 67). Although this statement may suggest that wonder precedes participation, perhaps to even approach the world, we must first perceive a world and this perception must be grounded in prior contact. As we increase in age and experience we are able to wonder about more abstract ideas, but as children, we rely on active participation to stimulate wonder, answer our questions, and order the world.

Perhaps by turning to the words of the girls in this study, we may discover additional clues about how they perceive the science curriculum they are exposed to during active participation, and if it presents an enhancement or diminution of hands-on activities.

1. We Don't Really Need It:

17. Sandy: ... I prefer when the students can take activities ... but I also like it when the activities are interesting.

18. Jenny: ... [science] might help a bit, but it won't be a big part of my life.

Although the girls were enthusiastic about taking part in hands-on activities, they questioned whether some content was truly applicable to their lives. Instead of seeing science content as an integral part of everyday life, they sometimes viewed it as something limited to science class. They also questioned if some science topics would ever be applicable to future life and personal career goals.

16. Jenny: ... Like, I don't want to grow up making batteries. It doesn't really help me at all ... it's not going to help me in my future.

35. Sandy: Well, it makes you aware of how things work. But, ... unless you're going to be an engineer or something, we don't really need it. But, it's interesting to know.

Perhaps these comments expose the failure of textbooks and lesson plans to provide explicit examples indicating how the subject matter is pertinent to the lives of eleven year old girls. Also, maybe curriculum content is an area where the girls may encounter a sexual bias because of their socialization into society. Although the majority of the girls specified science was for boys and girls, and careers in science were based upon personal interest and not sex, Liona pointed out that some careers such as electrician and plumber were dominated by men. She added that this was not because girls lacked intelligence for these careers, but rather they avoided them because they would experience the absence of female camaraderie.

30. Liona: ... you'll be the only one around when all the boys are around. You would be the only girl.

Perhaps these comments signify how important it is that we should take time to listen to students and include them in a re-evaluation of current curriculum. Additionally, maybe we should begin science inquiry in the actual wonder of the child instead of imposing topics with which they must attempt to identify. Further, perhaps as teachers we must strive to make the textbook topics interesting, personal, and relevant to the lives of our students. Bruner (1971) states that "what is important is to learn to bring all one's resources to bear on something that matters to you now" (p. 20). If we are to know what matters to children and what science or applications thereof

are personally relevant, then we should solicit students' opinions and strive to illuminate how the present curriculum can be pertinent.

By including the students in curriculum decisions maybe we can encourage a vision of science where people and their personal opinions are seen as a crucial part of the nature of science. Instead of seeing science as endless facts found in textbooks and encyclopedias, they will recognize it as a human activity springing from human wonder. Shattuck (1973) concludes:

> We strive to improve curricula, equipment, scope and sequence, grade placement, and objectives. Rarely do we attempt to improve in terms of people. In a sense we have succeeded in dehumanizing the stuff of scientific information. There is an urgent need to make subject matter relevant, and relevancy means that the subject matter should attempt to illuminate a student's value structure. (p. 260)

2. It's Going to Help You: Other times, the girls speak of science having a connection to their everyday lives, but the nature of this relationship seems questionable. Is it an association which illuminates their value structures and has personal meaning to them? Or, do they have to search to find even the vaguest link? Are there special times in their lives when school science seems applicable, or are they uncertain over even short term benefits? Perhaps the girls would answer all these questions affirmatively, but only the exploration of the nature of their answers can illuminate the sentiments they harbor toward curriculum content they see as relevant.

Several girls recognized school science materials as something they had also seen at home.

5. Alison: ... we use a lot of electric stuff ... doorbells ... magnets.

12. Alison: ... we use electricity for lights.

16. Jane: If you wanted to see if your batteries were working you could use just what we did today. And ... that's about it.

13. Jenny: ... it's going to help you ... if the lights all go out.

Whether this recognition of science materials can be construed as a personal identification with the subject topic is debatable. It may suggest that although some science apparatus is viewed as coming from their homes, perhaps it is materials with which other family members are more familiar. Maybe fixing doorbells, lights, and testing batteries are duties they do not normally perform at home because of their age, family circumstances, or socialization. This is not to suggest that they should not be exposed to these materials in science class or at home, but that their use in the curriculum should perhaps be preceded by a familiarization and discussion of the potential relevance to their lives.

Other students would repeat science activities at home. This suggests the interest some girls have in personally experiencing science that was demonstrated to them, and replicating activities which they had the opportunity to participate in first-hand.

32. Alison: ... after I brush my hair I put my comb near water to see if it will bend the water ...

22. Jane: Whenever we do experiments, I always go home and try them myself to see if they work out. And usually they don't. But, I still try them.

42. Melissa: ... we learn things how to do with nature, and things we can do at home and everything.

Perhaps these comments imply that wonder not only begins in prior life experiences but can be initiated through science activities which some girls may identify as related to their personal life. Maybe Alison saw brushing her hair and static electricity as something she had already observed, and to have it included in the science curriculum as part of a unit on electricity was an unexpected bonus. Perhaps these moments of personal identification with curriculum content should be amplified through encouraging children to express opinions on the relevancy of subject matter.

Two girls related school science to its eventual application in future roles involving the care of children. Jane felt that if she applied herself to school science, she could eventually employ it to assist in explaining school science to her own children. Alison mentioned safety rules that had been specified in science class and how they were valuable in protecting children from harm.

24. Jane: ... if your child's learning about ... something and they come home and they don't really understand it, you can help them with it.

26. Alison: ... when you're little, [you should] not play with fire.

Perhaps this anticipation of stereotypical child-caring roles suggest the influence of cultural expectations which may have been assimilated by some of the girls. Deckard (1979) states that by the time children enter adolescence "they are aware of, and have to a large extent internalized society's views of sex-appropriate attitudes and behavior" (p. 42). These internalized expectations could arise from parental, peer, teacher, and environmental influences. The present study does not contain interviews with boys, so it is impossible to ascertain if Jane's and Alison's comments are entirely based on their sex. Perhaps the area of sex-related preferences for curriculum topics in science presents possibilities for future research.

In addition to these comments, several girls spoke of extra-curricular activities which involved science they had initially been exposed to at school.

51. Sandy: ... I go to Girl Guides. We do a little bit of science ... we do nature stuff.

8. Melissa: ... I was in Girl Guides ... and we studied a whole bunch of plants and everything ...

59. Sandy: ... we went to [a local] Nature Center.

35. Jenny: ... we went on a field trip to [a local] Park and we learned a lot from there because we were doing a chapter in science about nature.

62. Sandy: ... when you're out there camping ... that really gets you more in tune with nature than when in the classroom.

During these times the girls were able to witness a link between school science and their everyday lives and to perceive mutual interaction between them. Perhaps it is significant that each girl referred to a topic in biology or environmental studies. Maybe this reflects a combination of the biological emphasis of the elementary science curriculum, environmental concerns of organizations they belong to, and a perception that biology has more relevancy and immediate applicability to their lives than chemistry or physics.

In summary, there is an overall sense that the girls do not experience an intimate and reciprocal relationship between curriculum content and their personal lives. Although they enjoy the opportunity to personally participate, at times they question the relevance of some hands-on activities. Perhaps choice of curriculum content is an area which is subject to numerous external pressures by virtue of being part of the educational system. Maybe exploration of the restrictions curriculum content is subordinate to can further illuminate why students lack opportunity to begin school science in personal wonder.

D) Impression of Science

60. Jenn: ... [science] shows you about the world and it helps you to understand about things.

42. Alison: ... [science] gives you more information so you know more about nature.

125. Jane: ... [science] helps you answer ... questions.

79. Sandy: ... it's made things clearer for me. You know how kids and adults, they always think like, 'Why does the world go round' and everything. It helps me understand why the earth turns and things. Why this happens and why that doesn't.

These girls have a view of science which includes a wonder about the world and a searching for answers. This quest for understanding takes place through being personally involved in the world, making predictions, enduring mistakes, and coming to their own conclusions. Perhaps this view of science was experienced and realized because of their opportunity to take part in hands-on activities. Whether this view of science allows for a recognition of the spiritual aspect of science, or the fact that science cannot answer all of our questions is debatable. However, the girls do know that sometimes school science allows increased awareness of the environment, communication of ideas, cooperation with others, and the opportunity to creatively exercise their imagination.

This image of science is elaborated on by Hawkins (1974) when he compares the gain in knowledge, increased confidence, and sense of involvement children associate with hands-on activities, to being at home in the world. "Part of coming to terms, of being at home, is in the sheer familiarity of the

environment and in the sureness with which one lives and walks there" (p. 3). Perhaps the natural probings and explorations the girls experience in hands-on activities are able to begin to transform science into an internal, creative life experience.

Further, Hawkins (1974) speaks of the liberation which comes from being able to participate in one's own inquiry of the world.

> If children are going to emerge from our schools secure in the practice and enjoyment of the arts of inquiry, it will only be because they have long practiced those arts, in engagement with the world around. In relation to science, this means that their involvement with it will have been of a kind such that we can truly say it has penetrated the subsoil of their minds and earned their loyalty because it has liberated them from the boredom and sophistication that comes with living in an unexamined world, because it preserves the freshness of subject matter and sustains emotion. (p. 12)

It seems the girls intuitively recognize the liberation and understanding which come from being able to personalize science in a concrete way. But this personal inquiry and freedom is tempered by curriculum content or lesson presentations with which they have difficulty identifying. Additionally, other forces limit the practice of active inquiry to the extent that it is not the dominant mode of investigation. It is as though the cycle of wonder, reflection, and action characteristic of science and inherent to life has been interrupted or broken by some discordant force.

Clearly, attention could not be given to the girls' experience of hands-on activities without also becoming aware that these events did not happen in isolation but were interconnected with a much larger picture. Perhaps the

descriptions and interviews not only disclosed an experience of science but also revealed the larger experience of school as seen through the subject area of science. Maybe their numerous comments about enjoying hands-on activities, the value of active participation, and hesitation over curriculum content could be further illuminated by reflecting on the structure of school and how it might influence their experience of school science. In the next chapter, then, I take another look at the girls' descriptions of school science, in an attempt to see how these descriptions might inform us of the child's world not just in science class but in school, and how school may, or may not be, in harmony with their lives.

VI EXPERIENCING SCHOOL SCIENCE: STRUCTURE OF THE SCHOOL

Introduction

219. Liona: The topic for this can't be science anymore ...

220. Int.: ... It's no longer how girls experience science, it's now more like ...

221. Sandy: ... how girls experience school.

222. Int.: How girls experience school.

223. Sandy: In general.

During the final group interview, two girls spoke about the wider perspective of school which had emerged over the course of the study. Although the interviews had focused on their experiences in science class, it seemed to them their words were in fact saying something about the overall school experience as lived by children.

This wider perspective seems to reflect ideas I have encountered in readings of science philosophy as well as the situational-interpretive methodology I have used which emphasizes that people are embedded in the world rather than isolated from their environment. Phenix (1971) has suggested that "any entity is constituted by the set of relationships that it has with all other entities. Thus nothing exists in isolation, but always in relation" (p. 120). To properly speak of how the girls experience hands-on science activities then, I not only have to attend to their experiences in science class, but also to how those experiences are affected by virtue of taking place in a school.

Even this, however, would represent an incomplete picture because the school does not stand isolated in society; it is influenced by the economic, social, and political landscape. Stake (1978) warns that in his experience "the case study ... proliferates rather than narrows. One is left with more to pay attention to rather than less" (p. 7). Stake is suggesting that case studies not only illuminate the complexity of human existence within some bounded system, but also that the boundaries we draw around our case studies are artificial and perhaps really exist only in our own minds.

Whitney (1983) observed this phenomenon in a case study which centered around the experiences of a group of grade four students in a social studies class.

> The initial parameters of the case were set around students' thinking in and about social studies. The research was to uncover their understandings of social studies and the use they made of such understandings for organizing their thinking. After the first few weeks in the class it became apparent that this was rather naive thinking! Student thinking could not be trapped neatly within the confines of one subject. While the fieldwork was still to be conducted during social studies periods the parameters of the study would have to be set by the students' thinking and not the researcher's plans. (p. 67)

As I studied the interview transcripts, identified similarities and discrepancies in the text, and looked for overall relationships among the spoken words, several themes emerged describing the child's world as seen through school science. These themes are quite possibly not the only ones around which the contents of the transcripts could be organized. They represent, however, one interpretation of the girls' thoughts and inevitably

they are shaped by my philosophy, past experiences, and reading of the literature.

In the preceding chapter, the girls described their experiences of hands-on science activities and specified a rationale for the inclusion of science in the elementary curriculum. During the discussion they identified themes of personal involvement, active participation, and sense of freedom as being associated with hands-on activities. Additionally, it became apparent that the frequency and content of hands-on activities were influenced by the surrounding school structure.

Against this background of their experiences in hands-on activities comes the influence of the school structure. This theme exposes how classroom science and activities therein do not stand in isolation, but in relation to the structure of the school and society in which they are a part. Children are not always able to participate in hands-on science activities, and the factors which serve to limit these experiences and the girls' description of other science activities are explored.

Finally, the girls describe their personal reaction to the school structure and subsequent feelings of estrangement from science activities which do not encourage personal involvement and active participation. Although they are <u>in</u> the school world, they do not seem to be <u>with</u> it in the sense of personal participator and re-creator. Instead, they use words which suggest they feel relegated to more of a spectator role.

This wider perspective of the structure of the school, and

how it influences children's experiences in elementary science is discussed in detail on the following pages.

A) Influence of the School Structure

1. Introduction:

> "Of course, teachers are not free to define the classroom situation in any way they choose."
>
> (Apple & King, 1976, p. 117)

When I was a practicing elementary science teacher I had to instruct within a variety of restrictions which served to dictate science topics and teaching strategies. Although I personally endorsed hands-on activities and was cognizant of the role they played in personalizing the learning, involving the students, helping children gain confidence, and allowing a greater sense of freedom, I found I did not have the license to consistently pursue this course of action. Instead, my enthusiasm for hands-on activities had to be balanced against time restrictions, availability of science materials, curriculum responsibilities, preparation for standardized achievement tests, and a host of more covert determiners.

The girls in this study were also aware of external forces on them which limited the frequency of hands-on activities. For them, the most visible symbol of restrictions was the teacher and they tended to attribute the frequency of active student participation, choice of science activity, limits to student

communication, and behavior controls predominately to him. However, Apple and King (1976) warn that

> The teacher's activities must be understood not merely in terms of the patterns of social interaction that dominate classrooms, but in terms of the wider patterning of social and economic relationships in the social structure of which he or she and the school itself are a part. (p. 124)

Teachers must work within a cultural milieu of values and norms to which they are bound. They rarely see any alternative other than conformity to the status quo and this, combined with their conspicuousness as representatives of the education system, serves to cause them to be frequently blamed for the shortcomings of school.

In this study, the teacher concurred with the girls that students learned science best through hands-on activities.

> Mr. B: ... if the experiment is well designed you introduce the concept to begin with, explain it to them, and then you do the activity. And if they can see it reinforced in the activity, well then, it really brings it home.

Of all the strategies used to present science in class, he personally prefers hands-on student activities or the teacher directed activity of teacher demonstrations. But, although he has observed that students are enthusiastic about hands-on science activities, he feels these must be balanced with desk work. In his opinion, activities also assist in developing questioning, inquiring minds in the children.

> Mr. B: I think that is the purpose of the science that we're taking, the STEM science, is to develop an inquiring mind. Try to encourage them to ask 'Well,

> what happens if I didn't do this, or I do this. will it work out differently?' And, that's not an easy task.

Although research suggests students learn best through hands-on activities, perhaps these activities do not develop inquiring minds. Instead, maybe children are inherently inquiring and a hands-on approach merely provides the opportunity for children to be personally involved, learning and enhancing what is already a natural part of their lives.

The teacher acknowledges that there are difficulties with implementing an activity science program. A shortage of science equipment, coping with discipline in a more open atmosphere, unfamiliarity with teaching strategies, long preparation time, and lack of background knowledge all influence the frequency with which hands-on activities occur. Stake and Easley (1978) observed similar restrictions in the schools they studied.

> Even those few who did like science and felt confident in their understanding of at least certain aspects of it often felt that they did not have the time nor material resources to develop what they thought would be a meaningful program. (p. 13:5)

In my teaching experience, I observed that teachers were compelled to operate within layers of bureaucracy where time schedules, curriculum outlines and standardized testing were handed down. They usually had minimal input into how these dictates could be adapted to the classroom and were further obligated to abide by behavioral and cultural norms to which society holds the school responsible. Apple and Kiem (1976)

comment:

> The school is a well-established institution, and it may be that neither the teacher nor the children can perceive more than marginal ways to deviate to any significant degree from the commonsense rules and expectations which make school school and not some other institution. (p. 118)

Educational institutions expect teachers to cope with a variety of time, curriculum, and physical plant restrictions. Daily, a teacher must deal with class timetables, school bells, and class switching. She must complete the science lesson on time so the children can go to gym class. Science must be terminated at a preordained time so she can switch classes with another teacher. The children must finish in five minutes because the recess bell is about to ring. Additionally, provincial Departments of Education distribute curriculum guides of subject requirements for which the teacher is responsible. Because teachers are evaluated, in part, on their ability to complete the curriculum, they must ensure accomplishment within the confines of the school calendar.

In addition to the restrictions listed above, Mr. B had the responsibility of alternating classes with a science facilitator. He had to keep on a strict time schedule and ensure he had taught the appropriate material that preceded each of her lessons. This strictly limited the amount of freedom he had to deviate from the prepared lesson plans to pursue topics of personal interest to the students.

Furthermore, the classroom in which Mr. B instructed could also have limited his choice of teaching strategies. There was

not any shelf or bench space upon which children could carry out hands-on activities. Desks had sloping tops from which materials could slide onto the floor. There were no sources of water or sinks. When children were assigned a hands-on science activity and materials were to distributed to them, they either had to sit on the floor and spread their materials around them, or cope with trying to perform the activity on their desks.

Forces outside the school building might also influence school learning and how students speak of education. The current economic condition of society has brought demands for increased accountability, back to the basics, and decreased school funding which could translate into an increased emphasis on evaluation, traditional teaching techniques and rote learning. Also, the students in our schools are exposed to a wide range of technological 'entertainment' which in contrast to some school learning may render it dull.

Perhaps our final reaction can only be amazement that teachers are able to integrate hands-on activities into their science programs. We could be forgiven wondering if hands-on science is not in reality at odds with the culture of the school and the expectations of society. Nevertheless, it is important to explore how children speak of school to discover how they interpret these numerous restrictions to hands-on activities, and how they are, to some degree, limited from the personal involvement and understanding which derives from being at home in the world.

2. Power of the Structure: Several aspects of structural and societal restrictions on school science have already been discussed. The girls tended to interpret these controls and their application to the variety of school science experiences outlined in Table 1, as being largely dependent on the teacher. During science lessons when they are not participating in hands-on activities, they felt teachers made decisions about which students could participate and about the amount of participation. Jane commented on how this was in evidence during teacher demonstrations when a restricted number of students were chosen to assist with the lesson.

51. Jane: ... we don't get to participate that much this year.

22. Jane: ... [the teacher] picks them [those who will be allowed to participate].

The girls also saw the teacher as controlling the type of written assignments they had to do and dictating the method of completion.

152. Jenny: ... we have to do them in the exact way and we don't have one single word to put in ...

111. Alison: [the teacher] wants to make sure we do it right and do it the way he wants us to do.

68. Liona: ... we did what we were supposed to do.

41. Jenny: ... Like, you have to have it exactly like this or else you can't do it at all.

Perhaps these remarks about other school science experiences can serve to expand our understanding of previous comments in which the girls indicated that they felt hands-on activities allow them to participate, become actively involved, and do science in their own way. When the children are given a hands-on activity, they all get to join groups or work independently. Materials are manipulated, learning is personalized, and school science approaches a harmony with life. But perhaps hands-on activities seem to promote feelings of independence and freedom only in the contrast they bear to other, more structured science experiences. Nevertheless, it seems that despite this comparison to other science activities, the girls still regard hands-on activities as allowing greater freedom to do science in some personal sequential order and creative fashion which, for the children, renders it an island of autonomy within a sea of structure.

The girls also made comments which suggested they see the teacher as controlling the timing and pacing of exams as well as desk work and written exercises.

108. Jenny: ... [the teacher]just gives some time.

103. Jane: ... [the teacher]gives us limited time.

18. Jane: ... I am pretty slow, so I run out of time.

113. Sandy: ... [it is to] speed you up if you're going too slow.

When I further probed about why they thought a teacher would limit time to complete assignments and exams, they were able to identify factors which suggested they were aware the teacher was being concerned about outside agents. One reason they gave entailed preparation for junior high.

114. Jane: ... they give you a limited time because in junior high you won't have that much time and you've got to get with it.

Furthermore, they were aware that their teacher was involved in switching classes with other staff members and knew of his concern for keeping both of his science classes on similar lessons.

118. Jane: ... when we go to social [studies] they [the other class] come in for science ... we just switch classes.

115. Melissa: ... the other class comes in for science for one period and sometimes they get a little bit ahead ... and [the teacher] wants us to catch up so he gives us limited time.

These comments illuminate the tension between the lived-time of the children and the clock-time of the school structure which leads to the girls' feelings of pressure.

105. Sandy: [timed tasks] ... make you nervous.

108. Jenny: [timed tasks] ... sort of bug you.

Perhaps these words highlight why the girls spoke of using their own time during hands-on activities and expose how the girls are aware the teacher is not totally free despite implications in the majority of their comments that he is all-powerful.

The girls also saw the teacher as controlling communication, movement, and behavior.

52. Jane: ... [the teacher]doesn't want to put her by me because we both talk a lot. To each other.

185. Liona: ... he tells me to sit down ...

8. Alison: ... [teachers]let you stay in your seats.

50. Sandy: ... they want you to behave yourself ...

Again, these comments could be compared to how the girls spoke of the socialization, communication, and freedom of hands-on activities. Maybe the girls feel these other science experiences are restrictive because they contrast them to the class atmosphere surrounding hands-on activities. Perhaps, however, it goes deeper than a simple contrast between science activities, and maybe they are really speaking of the cooperation, sharing, and personal involvement of hands-on activities, and how they feel dominated and become 'beings for others' during the majority of science experiences.

Trempe (1984) observed actions of domination in his case study of science classrooms and related it to his overall theme

of participant alienation from the school structure. "In the classroom, students obviously have no power at all" (p. 228) ... and "as for discipline within the classroom it is certainly not imposed by a democratic consensus, but dictated and enforced by the teacher alone" (p. 229). But, this should be no surprise. That is what makes school school, and all they are doing is mirroring society as a whole. We must all go to work, obey rules, listen to our bosses, and carry out their wishes if we want to remain employed. That is how life is, and far from being wrong it is what we accept and believe schools and society should be. We argue that control, domination, and restrictions are also characteristic activities of human life. But, maybe it depends on how we define life and living, and maybe restrictions, submission, alienation, and domination are idiosyncratic to our society and how we interpret it rather than characteristics of human life.

Greene (1978) argues that school is what it is because we interpret the school experience based upon the reference scheme of knowledge at hand. In other words, our perception of school is socially constructed through our personal interpretations beginning with the first time we hear the word school, subsequent observations of friends starting school, listening to how others speak of school, and culminating in our participation in formalized schooling.

> The crucial point is that we, as conscious beings, constitute the world we inhabit through our interpretations we adopt or make for ourselves. To take that world for granted as predefined or objectively there is to be uncritical,

submissive, and submerged. (p. 17)

In school, we have perhaps become so used to keeping children in their desks, separated, silent, and 'working', that we accept this as what should be in education. Additionally, we believe teachers should present the curriculum, follow criteria-based lesson plans, be in 'control' of students, and further accept that standardized tests provide numbers indicating the worth of our teaching. But, we must realize this is an interpreted reality and to accept these as givens without being critically reflective and asking 'Why?', is to experience a domination and submission of the self, a lulling to sleep of the senses, and what Greene (1978) calls mystification.

> The question of the freedom of those they try to teach, the question of their students' endangered selves; these recede before a tide of demands for 'basics', 'discipline', and preparation for the 'world of work'. Teachers (artlessly, wearily) become accomplices in mystification. They have neither the time, nor energy, nor inclination to urge their students to critical reflection; they, themselves, have suppressed the questions and avoided backward looks. (p. 38)

And so, by accepting what is as what must be, rarely questioning the interpreted structure of school, and restricting the personal agency of our students, we perhaps construct a school structure which mystifies and to some degree prevents students from experiencing actions enabling them to become more fully human.

What does this have to do with a group of girls enjoying hands-on activities in their science class? The girls spoke at length about the interest, enthusiasm, and sense of freedom they identified with hands-on activities. Maybe these activities are

not only an extension of their everyday life, but also provide an environment which serves to encourage what Greene (1978) calls wide-awakeness.

> The social philosopher Alfred Schutz has talked of wide-awakeness as an achievement, a type of awareness ... This attentiveness, this interest in things, is the direct opposite of the attitude of bland conventionality and indifference so characteristic of our time. (p. 42)

Maybe when the girls speak of doing hands-on activities in their own way, taking their own time, understanding, actively participating, and cooperating with others, they are experiencing moments of wide-awakeness. No longer are they controlled and submerged but understanding science in a personal way and beginning to move towards "significant, more understandable lives" (Greene, 1978, p. 49). Perhaps they experience a sense of being present to their selves, of identifying alternatives, making decisions, and proceeding in a way based upon how they personally interpret the world. In these moments, they come closer to participating in the human conversation, wide-awake and immersed in the world they share, encountering science as a characteristic activity of human life.

During other science experiences, participation, communication, and time are more explicitly controlled by the school structure. Although many teachers may describe these actions as times when they as teachers assert their rightful leadership role, preparing children for the world of work, restricting inappropriate behavior, and a traditional method of instruction perhaps it is because of their interpretation of school and acceptance of

existing structures. Freire (1970) has commented on the domination of school structure and resultant feeding of curriculum to students which he calls a banking concept of education. The result of banking education he writes, is students' creative power is minimized and they are oppressed within a structure that renders them "being for others" (Freire, 1970, p. 61). No longer are they actively becoming and developing their selves as they seem to do in hands-on activities, but are working towards external goals supplied by the structure.

The language of Freire seems strong, and perhaps we should stop to ask ourselves if children really are oppressed in school. When we think of oppression we may often conjure up visions of illiterate, poverty-stricken, peasants laboring under some military dictatorship in a Third World country and we immediately reject oppressed in light of the articulate, literate, well-clothed students in our classrooms. But Freire speaks of oppression in a broader sense, oppression meaning dehumanization of people which leads to a "distortion of the vocation of becoming more fully human" (1970, p. 28). Greene (1978) too describes schools as oppressive because they restrict us from envisioning and attaining what could be. Perhaps silent students, isolated from each other, excluded from the decision-making, and enduring alien curriculum are becoming human in some diminished sense of the word. Although they physically mature, and increase in skill and knowledge, they are not experiencing an immersion in the world, an autonomy, or a personal participation which enables them to become more fully human.

Greene (1978) suggests feelings of oppression can to a large degree be overcome by individuals who

> think about their condition in the world, ... inquire into the forces that appear to dominate them, ... and interpret the experiences they are having day by day. Only as they learn to make sense of what is happening, can they feel themselves to be autonomous. Only then can they develop the sense of agency required for living a life. (p. 43)

Maybe by inserting a critically reflective element into our science experiences, we can begin to overcome the taken-for-grantedness, mystification, banking model, and oppression found in the school structure. Perhaps hands-on activities currently provide the environment where students can experience the dawning of wide-awakeness, freedom, and familiarity with the world which encourages them to become more fully human, participate, and share in a moral life.

Perhaps this all sounds too vague or is a distortion of the image of school. Maybe all we can do is further explore how the girls speak of living school science within the educational structure. Only then can we begin to ponder these speculations and wonder if the majority of their science experiences encourage a "being for others" and only rarely, a "being for themselves" (Freire, 1970, p. 61).

3. External Motivation / Instrumental Values:

18. Alison: Well, nobody likes to get zeros ... like, they want to get their stuff right.

The girls commented on a number of external motivators which influenced them to achieve in school, to be concerned with

pleasing others, and to view school as a means to an end. Several girls spoke of parents and relatives who inspired them to achieve.

56. Sandy: ... And when I get a bad mark I feel like I kind of let myself down and my parents ... But, like my parents, they reward me, right? And they make it better for me to get good marks ... And my aunt, she says if I pass with honors she's going to give me this little diamond ring that she has. So they really make it worthwhile for me to get good marks.

22. Alison: Well, my mom says if I want to be a doctor I have to be good in science because lots of doctor stuff is in science.

117. Melissa: I come to school for my marks, to make my mom proud and stuff.

Perhaps these statements imply that interest in science, academic achievement, and willingness to adapt to the school structure may in part be a result of how others in their lives understand and value the school experience. Melissa also spoke of a more general desire not to lose face in front of her classmates.

8. Melissa: ... 'cause if I louse up, I kinda get scared like, that everybody's going to hate me or something.

10. Melissa: ... (if) I answer a question wrong I feel kinda embarrassed, so I don't want to answer another question 'cause I'm scared I'm going to get it wrong.

These comments seem to contrast with Melissa's previous statements in Chapter Five about independently persisting in hands-on activities and gaining in confidence. Perhaps during science experiences other than hands-on activities she is more conscious of being on display before class members and the potential public judgment that may entail.

Other students spoke of achievement in school as leading to scholastic progress, university, careers, and success.

130. Liona: ... I want to get a better grade to go in junior high. And I don't want to fail 'cause I'll be one grade behind.

6. Alison: ... going to university isn't that easy ... And so you have to study real hard and get good marks to be able to get in. So, I'll see how my marks are.

40. Alison: ... science is sometimes for work experience. Some people want to grow up to be a doctor or a scientist.

134. Jenny: ... I think the most important thing about school is the marks and education because when I grow up I want to get a good job.

135. Jane: We all do.

136. Jenny: I want a good report. I want to get a good education so when I grow up I can get a good job and I can be successful.

Stake and Easley (1978) encountered similar comments in their case studies with older students. They found that in science "what mattered most was what could be used in one's next studies,

and that those, or the ones after those, were related to what one would be doing on a job" (p. 12:22). I found it surprising that this group of grade six girls would also make strong reference to post-secondary education and jobs. Except for the statements they made in relation to hands-on activities and the nature of science, they didn't seem to relate science to wonder, personal involvement, sharing, and developing a sense of belonging.

Furthermore, perhaps there is a disheartening undertone to this optimism about the future. Stake and Easley (1978) observed that the public is perhaps less optimistic that schooling will lead to future employment and lifelong economic stability. But, despite this growing recognition "there is not a substantial turning away from the schools as the instrument of learning and socialization" (p. B:19). Greene (1978) also observed the public's continuing belief that our educational institutions will be the eventual panacea for economic woe.

> Research today points to the lack of correlation between schooling and economic success, but none of this persuades people not to put their faith in schools. When all else seems to fail, when people feel helpless about their own life situations, education is relied upon to prepare the children, at least, for mobility. (p. 58)

Perhaps these comments highlight how we should be critically reflective about the motivation for learning we encourage in schools and our perceived goals of education. This is not to suggest that we should tear down existing school structures, promote iconoclasm, and spawn a revolution, but that we should thoughtfully attend to the external motivation, instrumental values and interpretation of the world we are handing down to

students, and what the eventual effects might be no matter what the future is.

The girls also made numerous comments about their concern for attaining good marks on tests and report cards.

24. Jane: ... it all goes on our report ... I like to have a good mark ...

6. Jenny: ... you like to get good marks ...

108. Jenny: I think that's the only reason why half the kids in this school even come! They go for their marks.

A variety of emotions were identified as connected to these experiences of being evaluated, some positive

116. Alison: ... And I try to get good marks, everybody does. You feel good if you get good marks.

26. Jane: ... And if I get the same as a top student in our class, I feel real good about myself.

and some negative.

26. Jenny: ... the studying only gets you all nervous ...

12. Melissa: ... I'll get them wrong and I'll feel bad.

106. Jane: ... we don't even learn because we're so worried about the test.

These comments suggest that sometimes the girls experience

intrinsic rewards from test marks and are also concerned with their academic achievement. Perhaps this reflects the academic ability of the girls and the influence of others who encourage them to be successful in school. Stake and Easley (1978) observed that "the grading system was motivating for students who want the approval of teachers and parents. It had very little to do with producing or selecting students who would have a deep commitment to science" (p. 15:31).

This emphasis on pleasing others, being successful in schooling yet to come, attaining a successful future career, and making good marks leads to girls doing science not for the sake of personal learning, wonder, belonging, wide-awakeness, and becoming more fully human, but for external approval and rewards. A similar observation was made by Trempe (1984) who reasoned that this emphasis on external motivation and instrumental values was symptomatic of people being alienated from the culture in which they were physically situated.

> Self-estrangement, as the neologism suggests, is the state of an individual who is not connected as a person with his action, who is a stranger to it; in other words, he or she acts essentially to gain reward, not for the sake of the action itself. Thus to all intents and purposes, the action has purely instrumental value, and little or no intrinsic value. An example of a self-estranged person is a student who works solely to obtain marks, not to learn. (p. 227)

Do the girls in this study only try to achieve in science class because of marks? Perhaps achievement is also tied to other factors such as parental encouragement, a personal sense of responsibility, and future concerns which are part of the girls' socialization and maybe this enculturation does not

encourage the girls to learn because of a personal wonder about the world. Instead, they may miss out on the pleasure which comes from constructing their own reality, having a voice in culture's conversation and 'being for themselves' that is approached in hands on activities.

> In the meantime, they taste very little of the fruits of their labors (the satisfaction of knowing something new, the pleasure of mastering a new tool, the pleasure of meeting a challenge, the satisfaction of achieving something of value on one's own, whatever it be); they get marks! (Trempe, 1984, p. 249)

It seems that in the majority of science activities, the girls experience a sense of being controlled, oppressed, and submerged in a structure in which autonomy is replaced with autocracy, self-actualization with mystification, and wonder about our world with external motivation. Perhaps only in hands-on activities do they glimpse a vision of what science could be, a science which is essentially a human activity and characteristic of life.

Freire (1970) comments:

> In the last analysis, it is [people] themselves who are filed away ... For apart from inquiry, apart from the praxis, [people] cannot be truly human. Knowledge emerges only through invention and re-invention, through the restless, impatient, continuing, hopeful inquiry [people] pursue in the world, with the world and with each other. (p. 58)

Let us turn once again to the words of the children, and reflect upon how they describe their personal reaction to the school structure.

B) Child as In the School World

> Implicit in the banking concept is the assumption of a dichotomy between man and the world: man is merely in the world, not with the world or with others; man is spectator, not re-creator. (Freire, 1970, p. 62)

The frequency of hands-on activities is limited by numerous factors associated with the school structure and culture of which it is a part. This may lead to the adoption of instrumental values and reliance on external motivation in regards to school science. Perhaps a consequence of this pedagogy is children who experience uninvolvement and stand at the periphery of the learning. They discern science as being imposed upon them and something they are occasionally grateful to escape.

30. Sandy: ... sometimes I'm bored to death ...

42. Jenny: ... Today was one of the most boring days I ever had ... we've already seen it before.

46. Alison: ... sometimes I need a break, get away ...

Trempe (1984) also observed students in his case study who described parts of science as being boring and he argued that this was indicative of alienation and estrangement towards school learning. Perhaps the girls in this study were not bored because they were lazy or didn't want to achieve; but perhaps this boredom was an outcome of not being able to actively, personally participate in the learning.

Furthermore, the girls made comments which perhaps suggest a

disaffection from school science.

185. Liona: ... I'm sitting there waiting ... And I just sit there.

44. Jenny: ... we just had to sit there and watch.

52. Liona: ... I wasn't listening.

42. Jenny: ... they weren't paying attention.

Jenny argues that if you are sitting uninvolved and silent, then why even bother coming to school.

194. Jenny: ... Because I mean, if you're never going to talk through the whole school year, then there's really no reason why you should be coming anyhow ...

When students speak of sitting, waiting, being bored, and not listening, it is perhaps characteristic of being prevented from making a home in the classroom. They feel a gap between themselves and school science which they feel powerless to bridge.

It seems, however, that the girls are able to live with the basic contradiction of not being a part of the majority of the learning. Trempe (1984) argues "those who fully accept the unspoken reality, the 'drop-ins', adapt to the contradiction by striking a kind of balance which, though artificial and temporary, seems to suit them fairly well. The others feel hemmed in, uncomfortable and dissatisfied" (p. 249).

The girls only questioned these aspects of their experience

of school in the privacy of the interviews, perhaps their high achievement and conscientiousness reveals that in the classroom. they either do not question anymore, or they have adapted to the situation. If I were to use Trempe's terminology I would describe the girls in this study as the 'drop-ins'. Even though they were not 'with' the world of the classroom and sometimes spoke of their spectator role, they still believed enough in it to continue to take part when they could, to study for exams, and to behave according to some code laid down by the school structure. They have learned and more or less accepted the role of the student.

Bruner (1971) contends that our concerns in education should have to do with how we as teachers can give back initiative and

> a sense of potency. how one activates to tempt one to want to learn again. When that is accomplished, then curriculum becomes an issue again - curriculum not as a subject but as an approach to learning and using knowledge. (p. 20)

In elementary school science, maybe we have already discovered circumstances where students are enthusiastic and interested in learning moments when science is characteristic of human life and children feel at home in the world. If Trempe (1984, p. 245) is correct that "a person who 'belongs' is aware of himself or herself as an integral part of his or her environment and is in touch with others who share that environment", then maybe these same words can be used to describe hands-on activities and how we should work to promote increased science experiences of this nature. Additionally, we should encourage an element of critical reflectiveness in our science inquiry where wide-awake students experience science with the full concentration and total

absorption of being "wholly and fully human" (Maslow, 1973, p. 7).

VII TAKING A REFLECTIVE STANCE

As I survey the words that these girls spoke, read my personal journal, and remember the science lessons I observed, my overwhelming response is one of humility. When I taught elementary science I know that I spent class time in activities that allowed little student participation, were done according to my time schedule, and did not give the children a voice in their own learning. At that time I would not have described my classroom as oppressive, but efficient, accountable, well-behaved, and ordered. Classrooms are supposed to have a teacher in charge, children shouldn't be making a lot of noise, and marks have to be put on report cards. That's the way it is.

But, as I spoke with the girls in this study and listened to how they described school, I felt myself changing and beginning to understand how their experience of school was one in which control was exerted, power used, and daily lessons handed down down to them. Although for the most part they appeared to accept that this was the way school was, I think they still retained a sense of what school could be. And this story of their lives in school is one which must be told.

What is the merit of a study such as this? Why should we undertake trying to tell the story of children in school? Perhaps the rationale that best answers the question 'So what?' is the idea of bringing thoughts about education to the actual place where they are practiced. Aoki (1980) comments that:

We feel that for too long 'thought' and 'practice' have

> been set apart, an act which has tended to invite reified 'thought' on the one hand, and a-theoretical utilitarian 'practice' on the other. For too long, we have not been aware that second order thoughts were being 'applied' to the first order social world of practice. (p. 17)

Perhaps research which takes place in a classroom, and turns thoughtful attention to the actual events as they happen, as well as the words spoken by the participants, allows a mutual generation of thought and practice.

I will not be advocating here that schools should be totally changed, children should do what they please without any limits, or that we should incite a revolution. What I do want to say is that teachers and students should begin to thoughtfully speak with each other, to be critically aware of the system they live in, and to take a step towards the transcending of the teacher-student dichotomy.

There are a number of conclusions that could be drawn, implications that could be revealed, and recommendations that could be made from this study. Somehow, though, it seems contradictory that this study should be for the purpose of describing how it is for girls in school, and then I, the 'expert', should step in at the end to tell what this all means for the reader. And so, I asked the girls two questions which I hoped would reveal their thoughts on what school science should be. These questions were:

1. What would you like teachers to know about teaching children?
2. What would you like teachers to know about teaching school science?

Each girl spoke of her thoughts and hopes and as I listened I

couldn't help but feel that given the chance, these students could provide ideas on how to transform school science into a human conversation that would make it a characteristic activity of life. Their comments are detailed in the following sub-sections and as I discuss them, I take the liberty of showing how their words parallel those of several distinguished educators.

A) Implications and Conclusions

1. We Could Teach Them Things:

215. Jenny: ... But, now that we're older, maybe we know a few more things than maybe [teachers] do. And if we could talk a lot more in class, and if we could say a lot more, we could teach them things, and they could teach us things.

155. Jenny: And I think we should be able to do what we want to do and teach ourselves how to do these things ... have our freedom to do things.

In the above excerpts, Jenny speaks of how she wishes that her potential for teaching would be recognized. Although she knows that she is a student, she also sees that she could contribute to the instructing and sharing of some of the learning.

Freire (1970) comments that "education must begin with the solution of the teacher-student contradiction, by reconciling the poles of the contradiction so that both are simultaneously teachers and students" (p. 59). This blending of roles and subsequent dialogue can enable them to "engage in critical thinking and the quest for mutual humanization ... To achieve this, [the teacher] must be a partner of the students in his

[or her]relations with them" (p. 62). Freire states that in this atmosphere of education, "The teacher is no longer merely the-one-who-teaches, but one who is himself taught in dialogue with the students, who in turn while being taught also teach. They become jointly responsible for a process in which all grow" (p. 67). Greene (1978) adds that " [educators] and their students might well enter a conversation with one another, the kind of conversation that allows a truly human way of speaking, a being together in a world susceptible to questioning" (p. 69).

Jenny, Freire, and Greene all speak of the coming together of student and teacher to speak and learn from each other. No longer is the student sitting and listening while the teacher hands down a curriculum that even the teacher did not have a part in planning. Instead, "the teacher presents the material to the students for their consideration, and re-considers his earlier considerations as the students express their own" (Freire, 1970, p. 68). The students are seen as co-teachers, and the teacher, a co-student. Together, they learn, teach, and question as they live their lives in school.

2. A Bit More Understanding Science:

71. Jane: We need a bit more understanding science.

72. Int.: What do you mean, Jane, by a more understanding science?

73. Jane: Like, I mean, we need a science lesson ... that will teach us.

74. Int.: What do you want to know about?

75. Jane: Well, like, it will teach us in everyday life.

Like, when we have little kids ...

76. Jenny: Like the things we do everyday.

77. Jane: Yah.

79. Jane: Like, I like animals. That would be okay because you know if you have some pets at home ...

The girls were of the opinion that the school science they experienced was only marginally related to their everyday lives. They felt that a change should be made so that school science could, in part anyway, be seen to have its roots in and application to their lives.

Perhaps this transformation would naturally come about from the dialogue and reflection that was mentioned in the previous section. Freire (1970) contends that "Students, as they are increasingly posed with problems relating to themselves in the world and with the world will feel increasingly challenged and obliged to respond to that challenge" (p. 68). If our elementary science program can be open to dialogue, and flexible enough to allow for student lives to influence it, then perhaps children could not help but want to be involved and feel responsible for their own learning.

Greene (1978) comments that

> curriculum ought to provide a series of occasions for individuals to articulate the themes of their existence and to reflect on those themes until they know themselves to be in the world and can name what has been up to then obscure. (p. 18)

She adds that "learning must be a process of discovery in response to worthwhile questions rising out of conscious life in concrete

situations" (p. 19).

The girls, and these educators, are all making a plea for increased student participation in curriculum decisions so that they can begin to name their world, be one with it, and find a sense of belonging.

3. They Should Help Us Learn:

152. Jenny: I feel that school is for learning, and if we're going to learn, [teachers] should help us learn, not teach us how to learn.

215. Jenny: But now that [we're] getting older, [we] don't need [teacher instruction] as much because [teachers] have taught [us] enough now, now [we] should be able to figure out a few things [ourselves].

Jenny sees learning as something which is not handed down, but rather is encouraged and enhanced by a teacher-helper. She wishes teachers would recognize that as students grow older, they become more knowledgeable and capable of assuming responsibility for helping themselves.

Greene (1978) summarizes that "the objective of educators is to enable others to learn how to learn" (p. 3). She adds that "to come to reflect, to come to see is to learn" (p. 84). Therefore, perhaps when teachers encourage reflection and critical awareness within the classroom, they are helping students to learn about what is essential in life. It is not the endless memorization of facts for some test, but the ability to be thoughtful, critical, and independent in one's learning that is

essential.

4. More Freedom ... in a Certain Limit: The girls gave concrete examples of how they would like to increase their participation in the learning. They felt that both teachers and students should be able to use their own words to explain and speak of school science.

105. Liona: ... say it in your own words so we can understand it better.

152. Jenny: ... I think we should be able to say what we want to, I mean in a certain limit, and we should be able to do what we want, in certain limits.

Further, they felt that teachers should be more patient and allow the girls to work according to their own time. Teachers should also take time to speak about the lesson and help students who don't understand.

3. Alison: ... They should be more patient ... Also ... teachers, if they're nice, ... will probably listen to you more.

22. Jane: ... some teachers are not patient enough, you know.

31. Alison: ... if [students] don't understand something, tell them.

Finally, the girls spoke of the general sense of freedom for which they wished. They did not advocate anarchy, but rather, an

increased sense of freedom that was still contained within common-sense limits.

156. Jenny: ... I think we should have more freedom.

37. Sandy: ... you look for discipline. You don't want to go to a school where all they do is horse around all day because then you might as well stay home.

169. Sandy: ... I thought the teacher should give you more freedom, not to write on the walls or anything.

Suransky (1982) seems to agree with these comments on freedom when she states:

> A limitless situation throws the child into nothingness and does not aid in the humanization of the life-world of the child, for she then lacks the solidity of being. What is needed, however, is a flexible understanding of this dialectical experience in child-life. (p. 184)

This freedom with limits that is spoken of points to how the girls see participation and interaction as a key experience in school. This freedom is connected to naming the world "with which and in which they find themselves" (Freire, 1970, p. 70). Freire adds that:

> To exist, humanly, is to name the world, to change it. Once named, the world in its turn reappears to the namers as a problem and requires of them a new naming. [People] are not built in silence, but in word, in work, in action-reflection. (p. 76)

If it is true that the girls advocate a transformation of school science where they can take part in the teaching and learning, see the connection to their everyday life, assist in

curriculum decisions, and do it all within freer perceptions of time, communication, and movement, then what can we as teachers do to bring this about?

One suggestion that has already been made is that students and teachers should engage in reflective dialogue where together they name their own world. Greene (1978) directs further suggestions specifically to educators. She comments:

> I am convinced that, if teachers today are to initiate young people into an ethical existence, they themselves must attend more fully than they normally have to their own lives and its requirements; they have to break with the mechanical life, to overcome their own submergence in the habitual, even in what they conceive to be the virtuous, and ask the 'why' with which learning and moral reasoning begin. (p. 46)

However, Stake and Easley (1978) remind us that "schools are the offspring of society. They are both the image of society today and the shaper of society tomorrow" (p. B:1). This can be both discouraging and challenging. It may seem quite hopeless to advocate any critical thought in schools when this thinking is not encouraged in our society. On the other hand, by encouraging children to question and challenge the dehumanizing structures that we tend to describe as how life is, there is the potential for a gradual transformation of what we call school. Additionally, perhaps preservice teachers can be encouraged to reflect upon their own lives, and the career they are preparing to enter. Greene (1978) states that:

> Neither the teachers' colleges nor the schools can change the social order ... But something can be done to empower some teachers-to-be to reflect upon their own life situations, to speak out in their own voices about the lacks that must be repaired, the possibilities to be acted

> upon in the name of what they deem decent, humane, and just. (p. 71)

Perhaps Freire (1970) says it best when he concludes:

> [Human beings] are fulfilled only to the extent that they create their world (which is a human world), and create it with their transforming labor. The fulfillment of [humans as humans] lies, then, in the fulfillment of the world. (p. 141)

Perhaps these comments by the girls specifying a merging of the roles of student and teacher, a curriculum which has personal meaning to their everyday lives, a view of teachers as helpers, and an increased sense of freedom, echo their description of hands-on science activities. When the girls are able to begin in wonder, be personally involved, share with others, anticipate outcomes, and seek knowledge maybe they sense this is a time when they can personally create and participate <u>with</u> the world. Additional statements by Freire and Greene suggest that an element of critical reflection and thoughtfulness about how we interpret school, the underlying themes of the school experience, and the efficacy of people within the system should also be addressed.

I think these descriptions, observations, and suggestions combine to disclose the vision of science Bronowski (1978) was alluding to when he labelled it a characteristic activity of human life. A science where we experience fully, vividly, and personally what it means to wonder about the world, reflect on our existence, and be present to our self. A way of life which illuminates, extends, and preserves our primordial engagement with the world and leads to a human conversation where both

students and teachers can say they belong.

B) Recommendations for Further Research

1. Gathering Other Data: This study points to the idea that when we try to explain phenomena such as low enrollment in science courses, low achievement in science, and underrepresentation in science careers, it is important to examine the ground structures and themes of the experience of school. Factors which have been identified in research literature as influencing girls in science are enlightening, but they must be looked at within the overpowering framework of the school structure. Perhaps when we say that some girls feel alienated from science, we are also saying that some girls feel alienated from school and that alienation should be explored in a qualitative way. In this respect, phenomenology offers the potential to thoughtfully turn to some of the themes identified in this thesis in an effort to come to an even greater understanding of such themes as alienation, belonging, freedom, understanding, and learning, in the context of the school.

It would also be interesting to study a classroom somewhat different in emphasis from the one observed in this study -- a classroom where teacher-student dialogue, and student participation in the learning dominates classroom interactions. How would students in such a classroom describe their experiences of school science? How does the teacher cope in this different atmosphere and still satisfy the bureaucracy's demand for student behavior, report cards, standardized testing, and completion of the government curriculum? Or, could such a class ever in fact be

found? Perhaps another study might involve the piloting of this approach to science teaching and the subsequent discussion of how various participants experienced this process of education.

Another study could be comparative in nature and involve interviewing both boys and girls in the same science class. Maybe this would show similarities or differences between the two sexes. Other studies involving different grade levels in elementary school and children of lower achievement levels might also be interesting.

At this conclusion to my study I can't help wondering how Jenny, Alison, Jane, Melissa, Sandy, and Liona will experience school science in junior high. Will they still speak of marks and wanting to please, or will they increasingly speak of not caring and being disinterested? Will they still be pointed toward future education and careers, or will the current economic situation crush those hopes? Will they still speak of wanting to participate in school science, or will they give up? A longitudinal study with these same girls could begin to answer some of these questions and provide understanding of the relation between their lives and school as they travel through the educational system.

2. Using My Data:

> The first effort to research a new problem is most likely to be inelegant, imprecise, and crude. What one mostly learns from such first efforts is how it should be done better next time. But there is no way of bypassing this first time. (Maslow, 1966, p. 14).

The interviews with the girls, my ethnographic description of classroom interactions, and my personal journal notes provide data which go well beyond what is used or reported in this study. data which speak further of the experiences the girls had in school science. Hands-on activities encompassed only a portion of the classroom activities which took place. I have not yet explored those other science experiences fully because of typical and necessary limitations to the scope of a master's thesis, and because some of the themes which I felt might emerge from those data might be construed as somewhat sensitive in nature for the persons involved in this study.

Perhaps some of the restrictions to the content and extent of the discussion in this thesis could have been avoided through the use of alternate research designs and settings, but this insight only emerged upon completion of data gathering and the composing of an early draft of the present study. Nevertheless, the research design used was appropriate to the questions asked and if analysis is to be shared with study participants, then it is to be expected that revisions will occur. My personal experience confirms Maslow's (1966) statement about the trials of researching new questions in new ways. Perhaps only when we personally participate and become involved with searching for answers which matter to us, can we begin to learn what research, and maybe life, is all about.

A fuller analysis of the rest of the data available, however, would almost certainly be helpful in uncovering how the girls live the entire spectrum of school science, how they live within the school structure, and how they react to the limits of classroom

life. For example, what do the girls mean when they say, "I don't really understand the things we're reading out of the book.", what do they mean when they say, "People don't really think about what they're putting down on worksheets.", what are they telling us when they say, "I don't feel I've understood it enough because I keep asking questions about it." Perhaps the implications which arise from these statements, and the messages they contain for educators could be pursued in later discussions and papers, or even form the basis of subsequent research proposals.

Finally, perhaps this apparent conclusion to the study is really the beginning of my search for a science which does not stand alone within some fortress, but is interconnected with the world and which is essentially a human activity -- a science which is all about wonder, and life, and informing the "human vision" (Hawkins, 1974, p. 2). In this respect, maybe the present study actually represents the starting point or threshold of some journey along a path where we can experience science as inherent to life.

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APPENDICES

APPENDIX 1

Time Schedule

Date	Observation Time	Interviewee	Interview Interpretations
Friday, March 15	-	Mr. B	no
Wednesday, March 20	11:30-12 noon	Group Interview	no
Friday, March 22	-	Group Interview	no
Tuesday, April 2	9:05-10:15 a.m. 10:30-11:20 a.m.	Jane, Jenny, Sandy	yes
Wednesday, April 3	11:36-12 noon	Melissa, Alison	yes
Tuesday, April 9	10:30-11:22 a.m.	Liona, Melissa, Alison	yes
Wednesday, April 10	11:30-12 noon	Jane, Jenny, Sandy	yes
Tuesday, April 16	10:35-11:35 a.m.	Jane, Jenny, Sandy	yes
Wednesday, April 17	11:30-11:50 a.m.	Alison, Liona	yes
Tuesday, April 23	10:56:12 noon	Liona, Melissa. Alison	no
Wednesday, April 24	11:30-12 noon	Jane, Jenny, Sandy	no
Tuesday, April 30	-	Final Group Interview	no
Monday, May 6	-	Mr. B	no

APPENDIX 2

Sample Individual Interview

Alison - April 17, 1985

This interview begins with a discussion of the written interpretation from April 9, 1985. As Alison reads the interpretation, the following conversation takes place.

Int. = Interviewer

1. Int.: Nothing you feel I've said strangely or anything?

2. Alison: No.

3. Int.: I'm going to start out by asking a few questions about this just to clear up a few things I wasn't too sure about. And then we'll talk about the science lessons. First of all, right up here you talk about doing worksheets and they're boring to you because you think they just talk about what you've already talked about in the class. Can you tell me then, why do we do worksheets? Why do teachers give them?

4. Alison: Well, like some kids are not here to know that, so you could really know it, some kids are really not sure yet. So they, are not sure, they don't know that good so they do it to help them know it better.

5. Int.: So the worksheets help the kids who aren't so good in science? And seems that they probably didn't understand it the first time, then worksheets help them?

6. Alison: Yah.

7. Int.: But for you, because you probably did understand it, they are boring. Is that what you mean?

8. Alison: (nods yes)

9. Int.: Down here where you talk about your parents, are your parents scientists?

10. Alison: No.

11. Int.: Also, I want to ask you about your extra-curricular science activities. You said that sometimes when you're at home you'll do the experiment that you did in school. Are there any other things that you do outside of school that have to do with science? And I'm thinking of things like hobbies, or Girl Guides, or even a toy that you had when you were a kid that had to do with science.

12. Alison: Well, like, ever since I was little I wanted to be a doctor. And, like, my uncle, he wanted me to be one too. And like I had all sorts of little doctor toys. I had them and sometimes my uncle would visit me. He lives in Detroit now and he works there.

13. Int.: This is the uncle that you talk about there? (I point at the interpretation)

14. Alison: Yah, he's working there and he sometimes visits, but not often. And like when he brings some equipment, and I look at it and try it out.

15. Int.: Can you think of anything else that has to do with science? Do you go to Girl Guides or anything like that?

16. Alison: Well, I used to be in Brownies.

17. Int.: Did you do anything that had to do with science in Brownies?

18. Alison: Well, not much. We were going to go to camp but I didn't go. It was too expensive. There was a twenty dollars, and then ten dollars to go and twenty dollars to register and then you had to buy a Brownie dress. But, I didn't go. But in Brownies you mostly do like how to take care of the home.

19. Int.: And housework?

20. Alison: (nods yes)

21. Int.: You said that you think you might become a doctor. Could you describe what you think a typical day in your adult life would be?

22. Alison: Well, if you don't have a job yet, or you're in university, like you set the alarm, and get up, and do your stuff, and then make yourself breakfast, and take your books, and go to the university.

23. Int.: Okay.. How about after university when you're twenty or thirty years old?

24. Alison: Well, if you're married, well, I don't know. But, you wake up and then you have to make breakfast for your whole family. And if you have kids you have to make sure you send them off to school. Like, if they're little, you help them to dress and you help them make lunch at school. And then sometimes you clean the house. And then your husband, if there is, like if you have a husband, you help him make breakfast and then he goes to work. And when the kids come home you sometimes clean the house. And when your kids come back from school you fix them a little snack or something and tell them to do their homework, if they have any. And then your husband comes home and you have supper together. And then your kids ... and you watch TV together or something.

25. Int.: And you think that's pretty well what your life might be?

26. Alison: Yah, probably.

27. Int.: When you talk about being born with science talents, do all scientists have science talents?

28. Alison: Well, you have to have the interest to be interested in it. Like, some people they're good at drawing, but I'm not a good drawer no matter how hard, like, I try my best and it's still ugly. And some people, God gives you your talents. Like ...

29. Int.: Could you tell me what the science talents are? Could you list the science talents you are born with?

30. Alison: Well, the most important is your interest in science. If you're interested in it and then you have to work hard in science. And you listen to the teacher and stuff and you pay attention and you participate. And like you're here most of the days because if you're absent you miss a lot. And also, and then, like you do experiments and you participate more and that's basically it.

31. Int.: And these are the kind of things that you're born with?

32. Alison: Yah.

33. Int.: Where did you learn about science talents? Where did that opinion come from?

34. Alison: Like we have religion, like, a Catholic School. And we learn our religious stuff and the religion teacher, Mrs. A, she is in the other grade six class, like we

switch classes. Like, when we go in there she talks about, like expand your talents to your best.

35. Int.: So whatever you are born with, then you try to make the best of those talents?

36. Alison: (nods yes)

37. Int.: Alright. When things don't work out the way you thought they would in science, say you made a prediction about something and it didn't turn out that way at all. What do you do when that happens?

38. Alison: Well, not much. Like the boys, L.B. and Sam, whenever they make them they say, 'Oh, right' and stuff. Like they're real loud. They move around and they're happy because they're right. But, it doesn't matter, it's just a prediction, and it doesn't really matter. Like you're happy when you're right, but it's no big deal.

39. Int.: Do you think you'll take science in high school?

40. Alison: Yah, I think. Like I'm going to St. Jean and they don't give you options but, it's an academic school and I'm going to go there. And they say that they don't have art, but gym is an option and they might have music this year but the rest you have to take.

41. Int.: When you are in high school, do you know which science courses you will take?

42. Alison: No, I don't know.

43. Int.: You don't really know what's offered?

44. Alison: Yah, I don't know. I have no older brothers and sisters.

45. Int.: I'll just ask you a little bit about the science lessons now. Yesterday, Mrs. T was here and she started off with a filmstrip. And she stopped the filmstrip and she asked you questions. What did you think about those questions?

46. Alison: You had to listen to the film to get the questions. Like, we're just starting them. It was a pretty good film. The questions, like you had to listen carefully to answer the questions.

47. Int.: So would you say that they were hard questions or simple questions or what?

48. Alison: Well, they were about in between. Like you wouldn't

have known the answers if you weren't familiar with that topic.

49. Int.: After the filmstrip she brought out two batteries, Battery A and Battery B. And she had two boys come up and weigh them for the experiment. What sort of things go through your mind when the kids are picked to come up and do something and then the rest of the kids observe?

50. Alison: Well, lots of kids want to get picked. Like, I don't get picked much. But, it's kind of fun when you watch, and the kid that gets picked is pretty happy and excited, they get to do it ... like getting to use science equipment.

51. Int.: Does that help you learn how to use science equipment?

52. Alison: Well, like when you observe people you know if it's right or wrong. And then you improve your talents.

53. Int.: Now, you sit at the back of the row. Were you able to see the boys during the weighing?

54. Alison: Well, not much cause all the heads were in the way. But, Mrs. T tells you after what happened. But you can't see the best view.

55. Int.: She had you make a prediction about putting the batteries in the flashlight and letting them wear out. And some kids thought they'd weigh less, some kids said more, and some the same, and then she told you the answer. She said, 'They're going to weigh the same.' How did you feel when she told you the answer?

56. Alison: Well, like I thought that she wasn't supposed to tell. Like, that's what experiments are for. But, like she said that she wanted us to know before hand as it would take a long time to understand why she wanted to tell us first.

57. Int.: The last thing that she did was with the matches she lit and she put them on the scale. The people gathered around at the front watching. What sort of things did you think about when that was going on?

58. Alison: Well, it was kind of neat ... how it's really going to turn out, it's pretty interesting when you're not sure about stuff.

59. Int.: Would you say that something like that is one of the most interesting parts of science for you?

60. Alison: Like I said in this part, I like activities and experiments.

61. Int.: What did you think of today's class? It was mostly reading from the textbooks and you did the questions at the end. What did you think of that?

62. Alison: Like, it was alright, like it wasn't exactly that boring, but it wasn't that great either.

63. Int.: How would you have made that better?

64. Alison: Well, I would have done some experiments. Like the one at the top of the page. He said we weren't going to do that experiment.

65. Int.: On the last page you read? When you just read the bottom part?

66. Alison: (nods yes)

67. Int.: Do you think you're going to do that experiment?

68. Alison: Yah, I think so. He said we'll probably do it next time. But, I think we'll probably do it when Mrs. T is here.

69. Int.: When you take science in school, what is the main impression that you have? What is the main thing that goes through your head?

70. Alison: Well, I like science. And I'm pretty excited when science. Well, I can't really call it excited, but it's nice. I like science. And it's kind of exciting. I wonder if we're going to do experiments today and what new things I'm going to learn and things like that.

APPENDIX 3

Sample Interview Interpretation

Alison - April 17, 1985

This student describes worksheets as being boring. This is because she usually understands the concepts when the lesson is being taught and therefore finds the worksheets to be repetitive. She does realize that some students need these written exercises as they may not have entirely understood the lesson material.

Her extra-curricular activities in science are varied in nature. Sometimes she will repeat her school science experiments at home to see for herself if they work. She was also enrolled in Brownies, but she describes those experiences as being slanted towards traditional female tasks such as taking care of a home. When she was young, she would play with a set of doctor toys. This early introduction to medical interests was encouraged by both her parents and uncle and has resulted in her wishing to be a doctor.

Although this student seems definite in her choice of a future medical career, she gave a conflicting prediction of her adult life. When asked to describe a typical day in her adult life, she detailed a traditional female home-oriented day. She did not make any mention of daily tasks associated with a career in medicine. Instead her typical day consisted of housework, making meals, and attending to children. It seems that although she wants to become a doctor, when she is asked to describe a typical day she is 'brought back to earth' and feels that she will actually end up doing traditional female tasks in the home. Deep inside, this student wonders if she

will be truly able to escape from ending up being a housewife and working at some low paying part-time job.

People who do well in science are born with science talents. These talents are:

1. an interest in science
2. work ethic
3. paying attention in class
4. participating in class
5. good attendance

The student has this opinion as the result of the teachings she has had in her religion class. In that class the teacher has told them to expand their talents and do their best. There seems to be a conflict here between how the student and the teacher are defining the word 'talent'. The teacher seems to be talking about talents that children are born with such as a talent for music. The student's list of talents seem to outline abilities which are the result of how you have been brought up by your family. Perhaps when the student says that 'people who do well in science are born with science talents' she really means that 'people who do well in science have learned good habits of working in school'. + are born with science talents

Sometimes during class science activities, the children are asked to make a prediction. Those students who predict correctly are happy because they're right and it adds to their status in the class. For those who predict incorrectly, it's no big deal because after all, it was just a prediction.

This student intends on taking science in high school. She

doesn't know which science courses she will take because she is unfamiliar with the science choices in high school.

The student made several comments about yesterday's science class. She felt that the filmstrip questions weren't too hard, but you had to pay attention to the film if you were going to answer them. When the boys were weighing the batteries, she felt that it was fun to watch to see if they did it correctly, but it is much more exciting for the student who gets picked. She also had some difficulty in seeing the weighing due to her seating position. Fortunately, the teacher told them what the results were after the weighing was completed.

This student was disappointed when the teacher told them the 'correct' answer to their predictions before doing the experiment. She feels that the teacher shouldn't tell as that is what experiments are for. Also, it makes the activities even more interesting when you don't know how they are going to turn out.

In today's science class, she described the reading activity as not exactly boring, but not that interesting either. She would have preferred to do the activities as a way of introduction to the topic.

Her main reaction to school science is excitement. She finds it interesting and fun. She likes the idea of learning about new things that she never knew of before. Science is like an adventure that she wonders about and it makes her feel good inside.

APPENDIX 4

Sample Journal Entry

Tuesday, April 2, 1985

Finish taping at 12:07 p.m. and race out to my car. I eat my lunch as I drive back to university for my class. It seems that everything is being done too fast. I don't know if I have asked pertinent questions and I cringe at the anticipated vagueness of my transcripts.

I'm finding this experience to be a rushed one. As the science class is being taught, I find that I am unable to write down the lesson, observe the class, and pay particular attention to my key informants. I am so busy writing and following the lesson that I feel that I may be missing something very crucial that I have yet to identify ...

I guess that perhaps some of the problem is that I haven't yet sat down and pondered their words. Maybe once I do that, I will see the depth of reflection they do have and how we inevitably say more than our words.

APPENDIX 5

Teacher Interview

May 6, 1985

Int. = Interviewer

Mr. B = the Classroom Teacher

1. Int.: First of all, what is your general background and training in elementary science?

2. Mr. B: You mean at university? What courses?

3. Int.: (nod yes)

4. Mr. B: I took two first year science courses. Biology 230 and Chemistry 230 or 232, whatever the number. That's it.

5. Int.: Did you take any C.I. courses in elementary science?

6. Mr. B: No. I went the secondary route so I didn't take any elementary C.I. courses.

7. Int.: Did you take it at the secondary level?

8. Mr. B: No, I'm an English major so I took an English C.I., I started out in science and in my second year I switched over to English. Actually, I like science, and I still do, I still read science and that too. Science books.

9. Int.: Do you belong to any specialist councils?

10. Mr. B: No.

11. Int.: Any extra-curricular interests in science?

12. Mr. B: Well, yes. I read science, quite a bit.

13. Int.: You mean magazines?

14. Mr. B: And books sometimes. Science oriented books. Like, with nature, I live out on an acreage so we do a lot of ... We have a pond out behind our place and I go out there with my son and we catch minnows, and stuff like this. Water bugs, shells, and try to figure out what they are. Identifying birds, I try to do that kind of thing. See how many different kinds of birds I can see

back there. It's more the nature part of science that I'm interested in ...

15. Int.: More the biological.

16. Mr. B: Yes. The Space Sciences Center, I want to go there with my family. And that sort of thing you know.

17. Int.: Have you ever done any inservices in the science area?

18. Mr. B: Yes. Before we got our facilitator this year we went to an inservice just to orient us. But other than that, no.

19. Int.: That was orientate you to the Addison-Wesley Science?

20. Mr. B: No, that was in the September of this year that's when we got our facilitator, Mrs. T. It was to let us know she was going to be working with us and what she was going to be doing. What was expected of us. But it had nothing to do with the actual course. But with this, what they give you along with the facilitator, you get a set of lesson plans which makes it easier because you follow through these lesson plans and it kind of organizes the work a little better.

21. Int.: Why was the science facilitator originally requested?

22. Mr. B: I think you're eligible for one. In our school we can get a facilitator so any extra help you can get, you grab. Especially this way because you see her set up experiments. And if you've never seen them set up before it can be pretty tough. So she sets them up and you say, 'Okay, well, that's how she did it.' You know some experiments you always blow. Okay, I want to see somebody else set that up. How does she work it? How does she organize her groups? All this I found just incredible. Really helpful. You can watch somebody else do it.

23. Int.: So would you say that up to this year you weren't emphasizing an activity science program when you taught science?

24. Mr. B: Not as much. But I did try to get them what I thought were the easier activities, easier to prepare that is. I would do those. The ones that were harder I would try to do on a demonstration basis. A little bit like this year but not quite. Not as much. The thing is, the good thing about a facilitator is that you have to keep up. You have to keep pace with her. She does one lesson, you have to do the follow-up, and then she's

back for the next one. So you have to be finished. So it keeps you doing science. But if you're on your own, you have a very heavy math, to be perfectly honest, and a heavy L.A.. You know the end of the day is coming and you haven't finished your arithmetic yet. So the tendency is to steal from science and from French and things like this. It's too bad, but it happens.

25. Int.: So you almost have quite a time restriction then?

26. Mr. B: Oh, yes.

27. Int.: Especially with the science facilitator coming in this year?

28. Mr. B: Yes. With the facilitator you have to cover it. So you don't steal from that you steal from something else.

29. Int.: So it's very important in class to keep the kids moving on whatever the lesson is for that day and keep them on time because you have her coming in?

30. Mr. B: Yes, right.

31. Int.: Plus having to cover the curriculum in a year.

32. Mr. B: (nods yes)

33. Int.: How long have you been a teacher?

34. Mr. B: This is my fourteenth year.

35. Int.: How do you feel about teaching science? I guess you've answered a little bit of that already.

36. Mr. B: Well, I have mixed feelings. It takes so much time to prepare you know, you have to get all this material together and then you have to run through the experiment the night before at home. Because you don't want any surprises. And then it takes half an hour to prepare for any activity based lesson. Although, I enjoy doing it.

37. Int.: You mean to find the materials and that kind of thing?

38. Mr. B: Yes. Plus we have boxes with materials in them. But they're not usually complete. You usually have to get other materials from elsewhere. So I find science takes a long time in preparation.

39. Int.: These other boxes that you have, who put those together?

40. Mr. B: When the STEM program came out, each of the schools got together a box for each grade. In each of the schools. And they're supposed to be upgraded but I don't think they have been for the last couple of years.

41. Int.: Is one teacher given the responsibility to upgrade these boxes?

42. Mr. B: No, I think it is the administration that takes care of it.

43. Int.: The head office?

44. Mr. B: No, our administration right here. They get a group of parents together and the parents fill out what's missing. Because there is a list of what should be in the box right on the cover. They just check to see what's missing and they fill it out. I don't think they got around to it last year.

45. Int.: It sort of lapsed?

46. Mr. B: Yes. I find sometimes it's easier to just get your own materials. Because what is in the box is meant for just one demonstration lesson. If you want to do turbines with the whole class, well, you don't have enough materials. So I find it's almost useless. It's only good if you want to do a demonstration lesson. Then you might find the materials in there. But if you want to do it with the whole class, everyone working in groups, then you don't have enough materials.

47. Int.: Now, when you have to run out to Safeway, or whatever, to buy straws or aluminum pie plates, how do you do the financing on that?

48. Mr. B: I pay for that myself.

49. Int.: The school doesn't reimburse you?

50. Mr. B: Well, they might, but it doesn't cost that much. I just pay for it myself.

51. Int.: Is it school based budget?

52. Mr. B: No, it isn't. I could be reimbursed I think, but I haven't bothered even to ask. It doesn't happen that often that I have to buy something. I'm generous.

53. Int.: Do you teach science to other classes?

54. Mr. B: Yes, I teach two grade six sciences.

55. Int.: So you switch with Mrs. A? She does something for you?

56. Mr. B: Yes.

57. Int.: What do you see as the value of having science included in the elementary curriculum?

58. Mr. B: I like the STEM approach where they try to foster a scientific attitude. Questioning, inquiring. Because even the STEM book, which is not too old, it's already out of date. They're talking about nuclear energy for the future. Well, that's already passe. It's not so anymore. So you can't really be teaching science for concepts because they change so rapidly. So I think that the real value of it would be, and it's hard to do, would be to try to give them an inquiring mind when it comes to scientific things. So a lot of hands-on activity, the more of that sort of thing you could do, the better. Plus it gives you a break from math and L.A. which is a lot of sit down desk work. And then you can stick science in there which is kind of different. And it kind of breaks up the day for them. Plus, of course, a few concepts too. You want to work these in as much as possible. Although those things constantly change.

59. Int.: So you can see it as offering them not only concepts in science, but also an opportunity to break up their day and add sort of an inquiry attitude to the day.

60. Mr. B: I think that is the purpose of the science that we're taking, the STEM science, is to develop that inquiring mind. Try to encourage them to ask, 'Well, what happens if I didn't do this, or I do this, will it work out differently?' And that's not an easy task. That's out of character for teachers to do that because you want them to sit down, books out, 'Okay, you do numbers one through ten.' I feel comfortable in that type of an atmosphere. I think most teachers do. So to have them doing experiments is not natural, not for me anyway. I don't feel comfortable. I have to force myself to say, 'Okay, the object of the course is to do a lot of hands-on activities.' So you have to force yourself to do it that way and not do a lot of notes. Which is not really the purpose of the course. Although, you have to have a bit of that to back it up a bit.

61. Int.: I think that certainly the majority of teachers feel most comfortable with the desk work approach, and a

quiet classroom, and kids in their desks working. Do you know why that is? Have you ever had any thoughts on why we feel most comfortable with that kind of teaching and learning?

62. Mr. B: I'm not sure why. I just know I'm more comfortable with that. I don't know if I can tell you why.

63. Int.: Do you feel any pressures from other sources which you would sort of feel obliged to keep to that one way of teaching?

64. Mr. B: No ... I think there is always the fear that if you do too much hands-on kind of noisy type of activity that you're not going to be able to get them to sit down and do quiet work. You know, once they get into the idea of talking and making noise then your class is going to get away from you. But, I don't find that's really so. As a matter of fact, if you give them a chance for a little bit of hands-on kind of activity, it's easier later on to get them to do more desk work. Because they're not doing it all the time. They're not sick of it, not as sick of it as they would be otherwise.

65. Int.: Well, the next one again you've already half answered it. What do you see as important that students learn in elementary science? Would that be again the inquiry type of teaching?

66. Mr. B: I think so. Because if you can teach, plus a few concepts, some idea about science and that inquiry kind of mind. That scientific curiosity, it's not a measurable thing, and again, that's where teachers aren't comfortable. You can't measure that. How can you measure an inquiring kind of attitude? It's not definite. But, if you could do that, even if you could not turn them off on science, I think that would be quite an accomplishment. Keep them interested somehow.

67. Int.: What science content do you emphasize?

68. Mr. B: What do you mean?

69. Int.: Well, I know through the year you have to cover certain topics and in some classrooms there is a little bit of a slant one way or another.

70. Mr. B: Well, we have five chapters that we have to cover.

71. Int.: Five required chapters?

72. Mr. B: Yes. The first one is Changing and Preserving our Environment, that's my favorite. That deals with adaptation and that kind of thing. Then we do Light, the study of light, the bending of light. That's good because you have a lot of opportunities for hands-on kind of activities. Electricity, which is one we just finished, which is a good chapter too. And we do one on Energy, and Water. The study of evaporation and condensation.

73. Int.: Water cycle and that kind of thing?

74. Mr. B: Yes.

75. Int.: I wanted to ask you what view of science you have. What is science all about in your eyes?

76. Mr. B: You mean as pertaining to students?

77. Int.: Or in general.

78. Mr. B: At the risk of sounding repetitious, being curious about things. Wanting to question, inquire. Having some idea also of how certain things work, like electricity, the concepts.

79. Int.: An understanding of the world around you?

80. Mr. B: Science should not be something that ends for you when you graduate from high school. You should be interested in finding out some more about science.

81. Int.: So it almost becomes part of your life-style?

82. Mr. B: Should be, yes. To a certain extent. You can't get away from the desk work in science either. You have to have something to evaluate. So you use assignments for that.

83. Int.: Do you find that your students have problems understanding the concepts in the elementary science program?

84. Mr. B: No, I don't think so. They're fairly simple concepts. There's not too much trouble there.

85. Int.: Do you find most of them do quite well?

86. Mr. B: The majority of the students don't have too much trouble understanding. The concepts are very basic concepts. I think the reason is they don't want to date

themselves. If you get too much into detail and then you're out of date. New information comes in and what you've been teaching is no longer relevant, no longer true. So when you're dealing with electricity, you're teaching with very basic concepts that can't possibly change. Like, you have two types of electric charges, positive and negative. You're pretty safe with that kind of thing. Positive charges repel, unlike charges attract. It's all very, very basic stuff. They do it deliberately so you don't get too heavy into the concepts. They keep the concepts simple and then they throw in the activities.

87. Int.: To back up the concepts?

88. Mr. B: Yes.

89. Int.: I notice that in most lessons you begin with review questions. Why do you do that?

90. Mr. B: Just to kind of keep them from forgetting what they took the day before. It kind of wakes them up. Throw a few questions out at them. And when you get to your next science lesson, well, you kind of add on what you took the day before. It's kind of like, it keeps it in their minds, it keeps them from forgetting it. So that when they do the test, you've done a lot of review questions already orally so it makes it a bit easier. I find they do better on tests when you do that. When you start out with review, when they do the final test they tend to do a little better.

91. Int.: So you think all your students would benefit from this kind of review?

92. Mr. B: (nods yes) You can't spend too much time doing it. Just a couple of minutes doing review, then you go to the new stuff.

93. Int.: While I was here you gave a test. Why do you give tests in science?

94. Mr. B: To see if, these tests are designed to see if they not only understand the concept, but can they understand it when it has been changed in form. And those are tough questions.

95. Int.: You apply it to a different type of problem?

96. Mr. B: Yes, right.

97. Int.: With the same underlying concept to it?

98. Mr. B: Yes. And this is where some of the activities come in. Because if they've done the activities, then they seem to have a broader understanding of the concept too. To see if they've mastered the material in the chapter, obviously. To a certain extent to see if they can use what they've learned in different situations.

99. Int.: And then these marks are then used toward the report card mark?

100. Mr. B: Yes. They tend to do very well in it. I think the average was 75 or something like that.

101. Int.: Do you find your report card marks are mostly A's and B's?

102. Mr. B: Yes.

103. Int.: Even for your lowest ability kids too?

104. Mr. B: I don't think I have one mark under 70.

105. Int.: They all seem to grasp it no matter what the ability?

106. Mr. B: Yes. There is no problem understanding any of the concepts.

107. Int.: How do kids learn best in science?

108. Mr. B: I think it would be through the experiments, if they're well designed. Some of the experiments are not that great. But if the experiment is well designed, you introduce the concept to begin with, explain it to them, and then you do the activity. And if they can see it reinforced in the activity, well then, it really brings it home. Otherwise it's just something to memorize, and some of them can learn that way, they memorize, and it's okay. They have the concept memorized. But if they can actually see it, and actually do experiments where the concept is in action, I think that really brings it. Like the bending of light, for instance, you can tell them, 'Okay, a prism can bend light', but it's not until they actually see the prism bend the light that you can really see their eyes light up and it really brings it home.

109. Int.: I observed a lot of different activities in your classroom: textbook reading; worksheets; questions; filmstrips; demonstrations; student activities. Just

a number of questions on these activities. First of all, the textbook readings, why do you read and discuss the textbook material?

110. Mr. B: You mean together as a class?

111. Int.: Yes, when either you read it or the kids read it out loud.

112. Mr. B: Rather than individually?

113. Int.: Or rather 'anything'.

114. Mr. B: Partly, I guess, is to introduce the concept, the idea that we're going to be talking about. Another reason is to make sure that it's read. For the poor readers, in science particularly, I figure, well, they have to be exposed to the material and you can't allow somebody who is a poor reader to have that hold them back. So I always make sure I read everything together with them so that everyone gets exposed to it. Whereas in reading, that's the idea of a subject like that, to increase your reading ability. So I make sure we read it over and everybody gets exposed to the material. So partly I guess it is to present the ideas.

115. Int.: To present the ideas, to give background knowledge, and also to cover it for the poor readers in the class?

116. Mr. B: Yes.

117. Int.: What do you find is the value of giving worksheets and also questions from the book?

118. Mr. B: Worksheets are for partly review and to see particularly those lesson tests. To see whether they understood what they were supposed to understand.

119. Int.: Are those also used towards the report card mark?

120. Mr. B: Yes. Partly evaluation too. I don't record all of them. Just every second one or so I'll jot down.

121. Int.: I noticed you demonstrated some of the activities. What do you see as the value of doing a teacher demonstration for the whole class at one time?

122. Mr. B: As opposed to having each of the kids do it themselves?

123. Int.: Yes.

124. Mr. B: Well, it depends on how complex the experiment is. If it's difficult to set up and the materials are expensive, well then it's simpler to do a demonstration for the whole class. The best thing would be to have the kids do it themselves. But often if you don't have the proper materials, if they're expensive, you have to opt for a one class demonstration. And of course that reinforces the ideas again. If they learned that a prism bends light, a demonstration of that will reinforce it in their minds a little more.

125. Int.: It gives them that to see.

126. Mr. B: Yes, exactly.

127. Int.: How about the demonstration you did with the tea kettle? Was there any other reason you would do that?

128. Mr. B: That was to show that steam can actually turn a turbine. We had to blow on it, we did the water, and then the steam.

129. Int.: Would there be a safety factor in there somewhere?

130. Mr. B: Oh, yes. That was the reason I did it instead of having them do it. Exactly, yes.

131. Int.: Of all these different activities, which do you personally prefer to do in science class?

132. Mr. B: If I have the time to set up, a good demonstration, or to have the kids do an experiment. If it's a good experiment, and if I have time to set it up, I prefer that actually. I don't mind that too much. I also like the desk work when everyone does a worksheet. I don't mind if it's a good experiment, something that will work and we can see results, like the electric ferry. Well, that's a good one to have them do. You can do that one as a demonstration, then you have them do it.

133. Int.: Would you say then, from what you've told me, that the kids are most enthusuastic about doing the hands-on type of activity versus doing worksheets or questions from the textbook?

134. Mr. B: Definitely it would be the hands-on. That's just my guess but I would think that's their preference. They'd rather do that. But, you have to have a balance. You

can't just do experiments because they don't do that in junior high. They have to learn there's work that goes along with it, like deskwork goes along with the experiments. Even if it's just recording the findings.

135. Int.: Is junior high science mostly desk work?

136. Mr. B: I think they have a lab once or twice a week where they actually do the experiment. And then they might have two or three actual sit down classes. I think that's the way they work.

137. Int.: With all these different activities, like worksheets, et cetera, have you noticed any preference based on sex? Do you think girls prefer to do one thing in class and boys another, or is there any difference at all?

138. Mr. B: I haven't really noticed any difference. I think the girls, I don't think it pertains just to science, I think they're more amenable to worksheets and that kind of thing. To work in general I find ... of course they get kind of screwed up in grade six ... they hit puberty and all that and go a little nuts. But, in grade five, they have this little crayon box with 101 crayons in there and they like to do, more than boys, worksheets and that kind of thing. I could be dead wrong on that ...

139. Int.: It could just depend on the personalities you have?

140. Mr. B: Exactly. It depends on the class you've got too. It varies so much from year to year it's hard to really ...

141. Int.: Come out with a very general statement on it?

142. Mr. B: (nods yes)

143. Int.: Over the years, have you noticed any difference between how boys and girls experience science, say, first of all in the amount they participate?

144. Mr. B: I think the boys tend to be a bit more not in the desk work part of it. But, when it comes to experiments and asking questions about things and wondering about how this works and that works, I think the boys would tend to have a slight edge over the girls. But again that's a generalization. It's just my own ... I think the boys would tend to be a bit more interested in science. Plus, although STEM is fairly easy concept wise, but the former Concepts in Science that we did before was pretty

heavy. And I found that some of the girls tended to be a little awed by it. Some of the boys too, mind you. But I think they tended to ... I think the boys identify with it more as a boys' kind of activity, science and this kind of thing. Whereas girls would be more toward reading and L.A. and tend to do better in that area. Boys, again I find tend to do slightly better in arithmetic. It's very often you find boys who are excellent in mathematics, but they can't read. But you don't usually find girls who are excellent mathematicians and can't read. So those science and arithmetic, it probably could just be the roles they are exposed to.

145. Int.: Something cultural rather than biological?

146. Mr. B: Right. You get variations on this though. It's kind of a tendency because you find some years just the opposite, when your girls are all good mathematicians and your boys aren't. So it's kind of hard to say this is the way it is.

147. Int.: From what you've said before, the girls prefer to do worksheets and boys the activities?

148. Mr. B: Yes, I think so.

149. Int.: How about attitudes toward science? Any sex differneces?

150. Mr. B: I think the boys again would have the edge. More positive. Because you often find boys who are poor academically. I had one in September who would really do well in science too. But you don't often find it in the case of girls though. If the girls do well, it will be in reading or L.A. and this kind of thing, but, they won't excel in science and not in anything else. The good students, the female honor students, will do well in every one of them. Arithmetic, science, doesn't matter. But those who are not honor students will not usually excel just in science or arithmetic. But you find that quite often in boys, for some reason.

151. Int.: How about the particular topic you're studying in science? Have you noticed any boy/girl differences?

152. Mr. B: I can't say that I have noticed any specific topic that one sex would be more interested in than the other. Just speaking generally you know.

153. Int.: What would influence a student to like or dislike science?

154. Mr. B: If it's female and they're not good academically, if they don't read or write very well, the only reason they enjoy science is that they don't have to know how to read or write to do it. So it's an area where they can use their God-given talents, their brains, to really show that they can do something. And I think if you get too academic in an area like science, you would turn these kids off.

155. Int.: Turn off the kids who are low in ability?

156. Mr. B: Yes. Who have an interest in science but aren't that good in anything else but they have that interest in science, and if you start getting too demanding, like you want a one page report of this stuff and that, and they're not good at reports but they're good at the ideas and the experiments and asking questions. I think you have to be very careful that you don't turn these people off. Because if you start treating science like another L.A. class, I think you'll turn a lot of students off of it.

157. Int.: Especially the students who are low in ability?

158. Mr. B: So you have to be kind of ... no doubt you are going to turn some off anyway, but you want to try to minimize it as much as possible.

159. Int.: Why do so few teachers have an activity based science program?

160. Mr. B: Because it takes a lot of work to do it that way. Often the experiments don't work out the way they should work out and you wind up having to feel, 'Oh my gosh, I wasted my time.' One hour spent making these turbines and they don't even work for Pete's sake. And then you really feel bad because you have three chapters in arithmetic that you're behind. You could have been doing that. Or you could have been doing something else. And you feel, 'I wasted my time.' Now, this is the way I feel anyway. But even if the experiments don't work out, you should do them anyway. You explain it to the children, 'Okay, why didn't it work.' Try to work through it that way. And you have to have pretty good control, like for an activity based ...

161. Int.: Like, discipline?

162. Mr. B: Yes. You have to know that your class will stay on task and do the experiment and won't start fooling around and doing something else. And I think everyone

tends to be a little insecure. So if you don't feel you have real good control, that means being able to keep the kids on task, I think you may shy away from these activity based projects. You would rather go towards something that has more control. Like, worksheets, and that kind of thing. So I think a lot of them may be a little scared to try it. Plus the work. There is a lot of preparation. You have to get all that stuff together. You have to run through it the day before and if it works, and with me invariably the day before you forget ... So it might work and it might not. But, if you set it all up and it doesn't work you kind of look a little foolish too. You can go the route, 'Okay, class, it didn't work. Why didn't it work? What might have gone wrong?' But at the same time you kind of feel foolish because it should have worked. So you're taking a bit of a risk. Even if you did it the year before, by the time you come to doing it again you almost have to run through it once more. Because you forget. You're not sure how you set it up the year before. You almost have to run through it the day before, at home, before you, it takes time.

163. Int.: Do you see any drawbacks to implementing the curriculum guide in elementary science? Well, perhaps one drawback would be that the curriculum guide emphasizes an activity program and you just talked about some reservations that you have.

164. Mr. B: I don't know what you mean.

165. Int.: Well, for instance, the curriculum guide emphasizes an inquiry approach to science. Would you say that that's something more difficult to do?

166. Mr. B: Definitely. It takes training to be able to do that. The big thing of course, is that nobody has any training in science. Like in the elementary area anyway. You come in and you teach all subjects including science even though you've had no C.I. courses or anything like this. And I think especially for the inquiry approach you need a couple of inservices or a facilitator who is very good at it and you can watch how she does it. And then of course you have an idea how to set up these experiments, how to group. These are all the things you don't usually do. And it's not always that easy to learn on your own. I find that you tend to repeat the same mistakes. But if you can have someone to coach you along, you learn much quicker. If you could have regular inservices, an afternoon where you could go and

they'll say, 'Okay.' And specific inservices like for Electricity, 'Here is a good way to set up the one on making the cell.' And they show you how to set it up. Grouping, 'It works good this way when you group.' And then you have some ideas that you can use.

167. Int.: So things that you can take back to the classroom and immediately apply?

168. Mr. B: Yes. Because it's so easy to just gloss over some of this stuff. 'Oh, I have to get all this stuff together, I don't know how to do it. I've never done this before. To heck with it. We're just going to read it together. And I'll tell them, try it at home.'

169. Int.: I'm sure even the majority even do it that way.

170. Mr. B: Because it's so easy to do, there's a tendency to want to well, just speaking for myself only, want to slip into that. It's something you should avoid.

171. Int.: I think lots do that and readily admit to it.

172. Mr. B: Yes. It's too easy to do. You should try to give it a fifty-fifty chance even if it doesn't work properly or things haven't gone that successfully, maybe they have learned something anyway.

173. Int.: Does the science facilitator work in any other classrooms in the school?

174. Mr. B: Yes, she does. I don't know how many schools, but she teaches one lesson and you do the next lesson. And we have a set of lesson plans that she follows.

175. Int.: She does grade six in this school?

176. Mr. B: The one six, and the grade four class too. She gets Friday afternoon off at St. Anthony's Teacher Center and I think what she does there is line up all her materials, for all the different lesson she's going to teach. Gets them all lined up. The science area is right there, so many materials she needs, she just signs out. There's no problem. She gets everything lined up on Friday and then she's ready to go.

177. Int.: Except she's got to carry it all.

178. Mr. B: You see a lot of these lessons, she repeats. She gets it lined up once and as long as you have your materials, she brings her materials.

179. Int.: How do you feel the children react to the type of lesson she does?

180. Mr. B: They seem to like it. I think it's a nice change for them. They don't always have to listen to me. They've got somebody else in there, which is good. They seem to be really receptive to her.

181. Int.: And they enjoy the kind of lesson plans that she presents?

182. Mr. B: They seem to. On the most part. There may be exceptions. But, from what I can see, they enjoy it, and they enjoy her approach.

183. Int.: Have you noticed any change in the girls that I talked to in science class while the study was going on?

184. Mr. B: They seem to be a little more sharp. Readier to answer questions. More aware. More willing to take part. At least at the beginning they seemed to be. It was as if they knew they were being watched. They were kind of performing, which is good. Anything to get them to listen a little better.

185. Int.: How about the rest of the class reacting to the study?

186. Mr. B: They didn't seem to have reacted at all. I didn't get any inquiries. No questions from anybody as to why these girls were leaving. Not directed to me. They might have asked them at recess time.

187. Int.: That's probably what they did.

188. Mr. B: But they didn't ask me anything at all.

189. Int.: How have you felt taking part in this study? Being almost a fringe part of it, I guess.

190. Mr. B: It hasn't affected me at all. Not one way or the other. I just tried to carry on exactly as I normally do. I didn't feel at any time that I had to perform. I just figured, 'Well, she wants to see a typical science class in operation', so I made sure I did the regular things and behaved as I normally would. At least I tried to. So, not consciously, it hasn't had any effect on me. I would be very interested in reading the results, though.

(concluding comments)

APPENDIX 6

Department of Elementary Education
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T6G 2G5

March 14, 1985

Parent or Guardian of _____

I am a graduate student in Elementary Science Education and I am currently engaged in thesis research for my master's degree. My thesis is entitled 'The Experience of Girls in Elementary Science' and I am interested in exploring how grade six girls speak of their school science experiences.

The classroom that I will be studying is the one in which your daughter is enrolled. I would appreciate it if you would grant me the permission to conduct several interviews with your daughter at school. This will involve discussing the experiences and meanings of school science that your daughter has and exploring how she came to hold her opinions. All study participants are assured of anonymity in the eventual thesis write-up.

I hope that this study will contribute to our understanding of elementary science from the perspective of the students, and help to assist in future program planning and curriculum development in elementary science education.

Yours sincerely,

Brenda J. Gustafson

Business Phone: 432-3913
Home Phone: 454-8295

I give my permission for _____ to take part in school interviews for the purpose of being included in the thesis entitled: The Experience of Girls in Elementary Science.

_____
Parent/Guardian Signature